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VOL. V.

Yours truly
Benj H Latrobe

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BIOGRAPHICAL SKETCH OF BENJAMIN H. LATROBE.

Benjamin H. Latrobe was born on the 19th of December, 1806, in the city of Philadelphia. He was the fifth child and youngest son of Benjamin H. Latrobe, well known as an eminent civil engineer and architect, in the early part of the present century, and especially in connection with the Capitol of the United States, the best features of which were designed and executed by him, although he did not live to complete the building. Mr. Latrobe, senior, was descended from a French Protestant family, which had emigrated to Ireland. His father was an English clergyman, but his mother was a Pennsylvania lady of the Antes family, well known in Montgomery county of that State. He emigrated to America in 1798, and being a widower, married, in 1800, the eldest daughter of Isaac Hazlehurst, a Philadelphia merchant, and also an Englishman by birth.

The subject of the present memoir was not educated for the profession he afterwards pursued, and to which he might have been so well trained in his father's office. He was intended for the law; and, although his father died when his son was but 14, his purpose in regard to him was adhered to, and having graduated at the Roman Catholic College of St. Mary's, in Baltimore, at the age of 17, he entered a law office, as a student, and was admitted to the Baltimore bar before he had completed his twentieth year. He went soon after to New Jersey, and commenced the practice of law in Salem county; but the climate not agreeing with his health, he returned to Baltimore in 1829. Having meanwhile discovered that the legal profession was not to his taste, he left it the following year and entered the service of the Baltimore and Ohio Railroad Company, as an assistant of Jonathan Knight, then Chief Engineer of that Company.

The brother of the subject of our sketch, J. H. B. Latrobe, Esq., the distinguished legal counsellor of the Baltimore and Ohio Railroad Company, was educated as an engineer; but maturity brought to him a taste for metaphysics and law, and they have each chosen the path for which nature intended them, and are leading men in their respective professions.

Benjamin H. Latrobe, being already an accomplished draughtsman, and a fine mathematician, soon rose through several subordinate positions, to the rank of principal assistant to Mr. Knight, and in 1832, began the location of the Washington Branch Railroad, under his directions. This service occupied him until the close of 1833. In the following year, he located that portion of the Baltimore and Ohio Railroad, between the Point of Rocks and Harper's Ferry, which had not been previously established by Mr. Knight, conjointly with the Engineer of the Chesapeake and Ohio Canal Company.

In the same year he reconnoitred and reported upon a railroad route from Harper's Ferry to Chambersburg, through Hagerstown, Maryland.

In 1835, Mr. Latrobe was appointed Chief Engineer of the Baltimore and Port Deposit Railroad, which was located and built under his direction from Baltimore to Havre-de-Grace, 34 miles. The features which distinguished this road were, 3 bridges of considerable length, 2 of them with draws, over rivers of moderate depth of water, but almost unfathomable mud. They were supported upon piles, and were the first long railroad bridges of this description erected in the United States. The ferry at Havre-de-Grace was also peculiar, the cars, with freight and baggage, being transported across the river, ¾ of a mile wide, upon tracks laid upon the upper deck of a steamboat, so as to avoid breaking bulk; a plan since adopted successfully upon other railroads in this country. Mr. Latrobe left the service of the Baltimore and Ohio Railroad, when he entered the other, in 1835, but was recalled in 1836, and appointed "Engineer of Location and Construction," by that Company.

In this capacity, he executed all the surveys, planned and superintended all the works of construction, with the advice of Jonathan Knight, the Chief Engineer. He remained in the service of the Baltimore and Port Deposit Railroad Company until the opening of that work in July, 1837, and thenceforward devoted his exclusive attention to the Baltimore and Ohio Railroad surveys, which were prosecuted during that year to Wheeling and Pittsburg, on the Ohio. In 1838 Mr. Latrobe made an elaborate report upon these surveys, which extended over a section of a mountainous country upwards of 300 miles in length and 50 or 60 miles in breadth, in a manner to give much professional credit to himself. It was through this able report that Mr. Latrobe became well known to the profession throughout the country, and he gained soon after a high reputation by a report upon the principal railroads of the Eastern and Middle States, in which he was associated with Mr. Knight.

In this year, also, the four inclined planes over Parr's Ridge were replaced by a railroad, with grades of 80 ft. per mile, as located by Mr. Latrobe and constructed under his supervision, and the general direction of the Chief Engineer. Some important changes were also made in the bed of the road, by which a part of its most objectionable curves were dispensed with.

In 1839 the Baltimore and Ohio Railroad from Harper's Ferry to Cumberland, 98 miles, was finally located, and its construction, upon the plans prepared by Mr. Latrobe and approved by Mr. Knight, commenced. The work of chief interest upon that part of the road were 3 tunnels— the longest 1,200 ft.—and several bridges of considerable magnitude built of timber, upon a plan approved by Mr. Latrobe, and in which arch braces were adopted, with counterbraces and tie-rods between them. The plan of these structures is fully described in Haupt's work on bridges.

This important division of the road was open for travel in November, 1842, Mr. Latrobe having previously been appointed Chief Engineer, upon the retirement of Jonathan Knight in April of that year.

After the completion of the road to Cumberland, Mr. Latrobe was occupied during the succeeding years, up to 1847, in a variety of duties, all of which, however, related to the extension of the railroad beyond Cumberland to the Ohio river. He reconnoitred the country through Virginia, in 1843 and 1844, and in the latter year pursued his examinations into Ohio, to the leading centres of trade of that State. He also visited Richmond during each winter of these years, in aid of the efforts the Company were making to obtain an acceptable right of way through Virginia, and was deputed by President McLean, then on the eve of his departure as Minister to England, to make the annual report to the stockholders, in July, 1845, and on his recommendation they rejected the Virginia law of that year.

The transportation department of the railroad from Baltimore to Cumberland, was also under his general direction during that time, and in 1846 the old plate rail track was replaced by T rail, and many additional changes were made in the road bed, and its most objectionable curves.

In 1847 the surveys west of Cumberland were resumed, and in that and the two succeeding years, the line to Wheel-

ing, 200 miles in length, was located, and most of it placed under contract. In the location, plans, and construction of this part of the Baltimore and Ohio Railroad, Mr. Latrobe performed a most difficult task. The country presented unusually bold features, even for a mountainous region. Two main summits, one of 2,600, and one of 2,000 ft. above tide water, had to be passed, with a valley between them less than 1,400 feet above the ocean. Lines of better grade might have been had, but with shorter curves and a greater expenditure of distance and cost of construction. Mr. Latrobe selected the most direct, and easiest to build, although it involved an inclination unprecedented in leading railroad routes.

The principal summit of 2,600 ft. above tide water, between the Potomac and Youghiogheny, was passed by a grade averaging 116 ft. to the mile, for 15 continuous miles. The same grade was used for $8\frac{1}{2}$ miles in descending to the valley of Cheat river; and in crossing the second summit of 2,000 ft., between this river and Tygart's Valley, about 6 miles of 105 ft. grade was used on either side.

Mr. Latrobe had adopted this location on his own responsibility, as the Company's Chief Engineer; but as it presented novel and important questions, a consulting board, composed of Jonathan Knight, Capt. John Childe, and himself, was appointed to consider the subject. Under the direction of this board, new surveys were made in 1848, which resulted, however, in showing that the best ground had already been selected; and in an elaborate report, made soon after, the location of Mr. Latrobe was approved by his colleagues, and finally adopted by the Company.

The road was accordingly constructed upon that line, and its natural features, and the works connected with them, have become well known throughout the country. Upon the 200 miles between Cumberland and Wheeling, there are 12 tunnels of various lengths,—the longest, the "Kingwood," 4,100 ft.—through a compact slate rock, overlaid in part by a good limestone roof, and for the rest of its length supported by brick arching. There is a long deep cut at each end of the tunnel. It was worked from both ends, and from 3 shafts 15 by 20 ft. sq., and 180 ft. deep. The greatest height of the ridge over the tunnel is 220 ft. The time employed on the work was about 2 years and 8 months, and the number of cubic yards removed in the tunnel, was about 90,000, together with about 110,000 yards of earth and rock outside, for the approaches.*

The next most important work was the "Doe Gully" tunnel, 1,200 ft. in length, where a bend in the Potomac river is crossed, and a distance of nearly 4 miles saved. The approaches to this work are imposing; for several miles on each side of the tunnel, the road occupies a high level on the steep hill sides, affording an extensive view of grand mountain scenery. The tunnel is through a compact slate rock, which is arched with brick to preserve it from future disintegration by atmospheric action. The fronts or façades of the arch, are of fine white sandstone, procured from the summit of the neighboring mountain. The height of the hill above the tunnel, is 110 ft. The excavations and embankments adjacent, are very heavy, through slate rock. The bridges are also numerous, and the "trestling," across the gorges, on the ascent of the Cheat River Hill, are structures of novel character, being viaducts supported by slender pillars of cast iron, very light in appearance, yet strong and durable. One of these viaducts is 46, and the other 58 ft. high; the former resting on a solid wall of masonry, whose foundation is 120 ft. below the base of the columns; the latter on a similar wall, with foundations 74 ft. below base of columns. The pillars lean inwards to give stability, and are thoroughly tied and braced, and carry 2 tracks of rails at the grade of the road.

In the design and erection of the bridges and viaducts, Mr. Latrobe was assisted by Albert Fink, a talented German engineer, who was associated with Mr. Latrobe as an assistant for several years, and is now earning a high reputation as an engineer and bridge architect, in the South-West.

The cost of the Baltimore and Ohio Railroad from Baltimore to Wheeling, 379 miles, completed June 1, 1853, was

* At the crossing of the mountain over this tunnel, previous to its completion in 1853, the grade was upwards of 500 ft. per mile, over which a locomotive engine propelled a single car at a time, weighing, with its load, 13 tons, at a speed of upwards of 10 miles per hour. When the track was wet or frosty, the engine and its load occasionally slipped backwards, and often ran with locked wheels, down to the bottom of the grade without injury.

$15,629,000, including nearly $1,000,000 for reconstruction east of Cumberland, after the road was opened to that point in November, 1842.

The working of the Baltimore and Ohio Railroad, between Cumberland and Wheeling, has abundantly manifested the judiciousness of its location and manner of construction. The high grades have been operated with great economy and entire safety, by means of a class of locomotives, using the extremely cheap mineral fuel which abounds in that region. In addition to the work already described, and upon which Mr. Latrobe has been engaged as Chief Engineer, he acted, from 1850 to '54, as Consulting Engineer of the Cincinnati, Hillsboro and Parkersburg Railroad, and in 1855, the Fredericksburgh and Gordonsville Railroad Company employed him in the same capacity.

In 1854 he visited South Carolina to examine the location of the Blue Ridge Railroad of that State, upon which he made an able report of some length, which was published by that Company. He again visited the road in 1857 to give his professional testimony upon questions connected with the object of his previous visit.

In 1851 Mr. Latrobe was appointed Chief Engineer of the North-Western and Virgina Railroad Company, extending from Grafton, a point on the Baltimore and Ohio Railroad, to Parkersburg on the Ohio river, 92 miles below Wheeling. In the contest for the right of way through Virgina for the Baltimore and Ohio Railroad, Mr. Latrobe always favored the most direct line to Cincinnati, and opposed the Wheeling terminus. He, therefore, entered *con amore* into the construction of the Parkersburg Railroad, under the charter which the citizens of that place had succeeded in obtaining.

The country between Grafton and Parkersburg was very much broken, and required patient examination to secure the best line, which was only obtained by a free resort to tunnelling through the numerous high and sharp ridges dividing the many watercourses. No less than 23 *tunnels*, in 104 miles, had to be driven, the longest 2,700 ft. These tunnels are the most striking features of the road. There are many bridges, but none of great magnitude, and several embankments, but none of extraordinary altitude or length. The depot arrangements upon the Ohio river at Parkersburg are worthy of attention, for their excellent facilities for handling freight by means of machinery used for raising and lowering it from steamboats.

In 1856, Mr. Latrobe was appointed President of the Pittsburg and Connellsville Railroad Company, and also of the Northern Virginia Railroad Company. From this last position he retired in the latter part of 1857, and devoted his whole attention to the direction of the Pittsburg and Connellsville Railroad, performing, from early in 1858, the duties of Chief Engineer of the same Company. In 1864 he retired from the Presidency of this Company, retaining, however, the Chief Engineership, which he still holds.

In 1863 he became Consulting Engineer of the Philadelphia, Wilmington and Baltimore Railroad Company, in connection with the bridge then about to be built across the Susquehanna river at Havre-de-Grace. In 1865, he was appointed Consulting Engineer of the Missouri Railroad Company, more especially in reference to the bridge about being erected over the Missouri river at St. Charles, which position he held for about two years.

In 1866 he was appointed Consulting Engineer to the Governor and Council of Massachusetts, in connection with the Troy and Greenfield Railroad, and Hoosac Tunnel, and held the office until January, 1869, when he resigned.

Early in 1869, on the invitation of the late John A. Roebling, he became one of a Consulting Board of Engineers upon the plans of the "East River Suspension Bridge," and continued to act with the Board until its services were terminated, and report made in the autumn of the same year.

Such is a brief summary of 40 years of the professional life of this distinguished Civil Engineer. In looking through the numerous reports from his able pen, the author is at a loss to select from among them such as might be considered most worthy of notice and deserving of preservation as part of the professional history of his time.

In 1846, when the Baltimore and Ohio Railroad Company was hesitating whether

it would extend its road west of Cumberland to Pittsburg through Pennsylvania, or to some Point below on the Ohio, in Virginia, the Pittsburg and Connellsville Railroad Company, having located a part of its road, offered its charter to the Baltimore and Ohio Railroad Company (to whom Pennsylvania had refused to renew its former right of way on terms that would be accepted).

The Company decided, however, to go through Virginia rather than through Pennsylvania, even if they were compelled to make their terminus on the Ohio as far down as Wheeling. This decision was an unfortunate one for the Company ; for if the road had been first made to Pittsburg, the State of Virginia would have finally accorded the right to Parkersburg (as has since been proved), and the 100 miles to Wheeling would have been saved, and could well have been spared, for in the final arrangement it has become mainly a local road.

Mr. Latrobe is now engaged in endeavoring to accomplish that which he desired to have seen effected at first, and should he be so favored, may live to fill up the measure of his professional ambition—the completion, under his direction, of two great lines of railroad which are equally necessary to Baltimore.

He has been invited to take charge of other lines of railroad, but the interest he has always felt in the city of Baltimore, and the completion of her connections with the West, has always led him to decline engagements incompatible with that paramount object of his career as a Civil Engineer.

Mr. Latrobe is as distinguished for his modesty, urbanity, and gentlemanly deportment, as for his eminence as an engineer. When complimented on the opening of the Baltimore and Ohio Railroad, at the Fairmount banquet, he characteristically replied, in part as follows:

"The merit which has caused my name to be mentioned in this connection, would doubtless have been exhibited to the same extent by any other professional man, who had the same opportunity of constructing a similar road over such a country. The general maps indicated the courses of the streams that were to facilitate the work; but where the mountains were to be crossed and tunnelled, and the rivers to be spanned, was a matter of careful examination, in which I was aided by the talent and perseverance of skilful assistants, whose valuable services I shall always take pleasure in acknowledging."

In another place he says: "In crossing or tunnelling the mountains, and spanning the rivers, sometimes one plan had to be adopted and sometimes another, and I have been constantly surrounded by able and accomplished assistants, to whom I take pleasure in according their share of whatever merit there may be found in the task I have accomplished."

A less sanguine temperament than that possessed by Mr. Latrobe would have recoiled from the task he saw before him, but its very difficulties seemed to give the work new attractions.

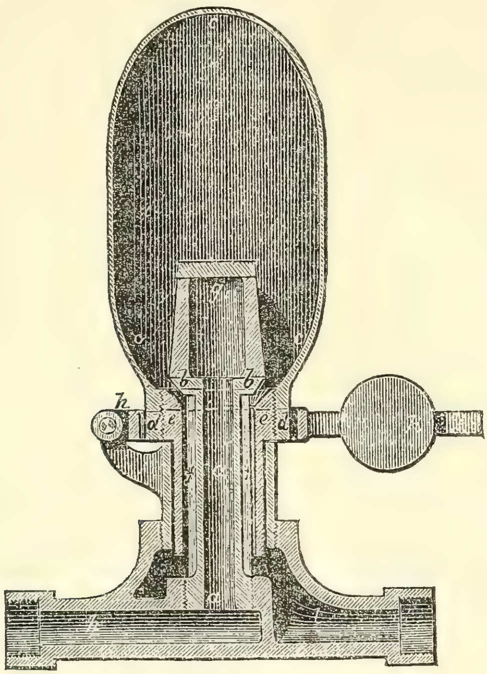
These works, from the Chesapeake to the Ohio, are a noble monument to his professional skill and indomitable perseverance.

CHATWOOD AND CROMPTON'S STEAM TRAP.

From "Engineering.'

We subjoin an engraving of a form of self-acting escape valve for drawing off water from steam pipes, etc., which has been designed and patented by Mr. Samuel Chatwood and Mr. James Crompton, of Bolton. The apparatus consists of a short vertical pipe open at the top, which should be at a lower level than the cylinder or other steam vessel to be drained. Around the upper part of the pipe is formed a valve face, the face being downwards. The upper part of the pipe with the valve face above-mentioned is enclosed within a small vessel closed at the top, and having at its lower end a neck, which fits on a parallel part of the pipe below the valve face, and carries a corresponding valve seating set with its face upwards, so that when the vessel is lifted up the valve and seating are in close and steam-tight contact; and when the vessel drops, the seatings separate and allow any fluid contained in the vessel to escape through grooves or openings left in the neck.

The action of this apparatus is as follows: When steam only is in the pipes the vessel is pressed upwards owing to the internal area of the vessel being greater at the top than at the bottom by the amount of the area of the valve face, and thereby the valve and face are closed together so as to prevent the escape of steam. When water is formed in the pipe by the condensation of the steam, it gradually accumulates in the closed vessel, until by its weight it overcomes the upward pressure of the steam, and causes the vessel to drop, thereby opening the valve and allowing the water to flow out through the openings in the neck until the weight of the vessel and its contents falls below the upward pressure of the steam, which then lifts the vessel upwards again, thereby closing the valve and preventing the escape of any steam. There is placed above the mouth of the vertical pipe above-mentioned a guard, against which, when the valve opens, the condensed fluids are driven by the pressure in the steam vessel, so that by their downward reaction they tend to keep the vessel down and the valve open until the



vessel is empty or nearly so. The designers also apply a weighted lever to the closed vessel, by which the valve may be weighted more or less by moving the weight along the lever so as to regulate it to suit the pressure of steam in the engine or other steam vessel to which the apparatus is applied. The same end may also be effected by applying weights directly to the valve without the intervention of a lever, or spring might be employed in place of a weight.

The annexed figure shows one arrangement of the apparatus above described. In this figure, *a* is the short vertical pipe having the valve face, *b*, at its upper part; *c* is the vessel closed at the top, and having at its lower part the neck, *d*, which carries the valve seating, *e*, corresponding to the valve face, *b*; *f*, *f*, are the grooves through which the condensed liquid is to escape; *g* is the guard carried above the upper end of the vertical pipe, *a*. The steam enters at *k*, and the condensed liquid is conducted off through the outlet *l*. The shape of the casting forming the lower part of the apparatus may be considerably varied. The weighted lever shown at Fig. 1 for drawing downwards the vessel, *c*, is marked *h*.

AN ELEMENTARY AERONAUTIC APPARATUS.

Translated from "Les Mondes."

M. Foselli, during the progress of the siege, has being very seriously studying the problem of navigable aeronautic apparatus. We shall not presume to say that he has solved the problem, but his attempt certainly presents some new and ingenious peculiarities. His *aerostat* is a simple cylinder terminated by a cone intended to cleave the air, and surmounted by cones called *compensateurs*, which, by means of a very simple apparatus, may be made salient or re-entrant, so as to equilibrate all the variations in pressure of the gas ; so that it is not necessary to throw out ballast, or to let off gas, in order to rise or descend. The cylinder is firmly fixed to a metallic chamber or cylinder with inflexible walls, of the same length as the machine. The chamber carries at its extremities propellers or helices which are intended to drive and guide the vessel. It is divided into compartments, each having its special use. One is hermetically sealed and is to hold atmosphere to be breathed when at a very great height. M. Foselli does not think it possible to steer in the disturbed atmosphere of the region of snows; but intends to reach that great elevation in which there is absolute calm. He estimates that in the region of perpetual calms atmospheric tension is reduced to one-half of what it is at the surface of the earth. Hence it was necessary to assure himself by rigorous calculations that it would be possible at so great an elevation to introduce sufficient air into the living chamber to maintain an atmospheric pressure of 750 millim., which is necessary for the normal action of the essential organs of life. M. Foselli was much surprised at finding that the arm of a single man acting upon a small air-pump will maintain, at ordinary tension, an amount of air sufficient for the respiration of several hundred persons.

In a very rarefied and calm atmosphere a very slight motive force, or a very small screw, is sufficient to make the machine move, even when loaded. The experiments leave nothing to desire; the results are decisive.

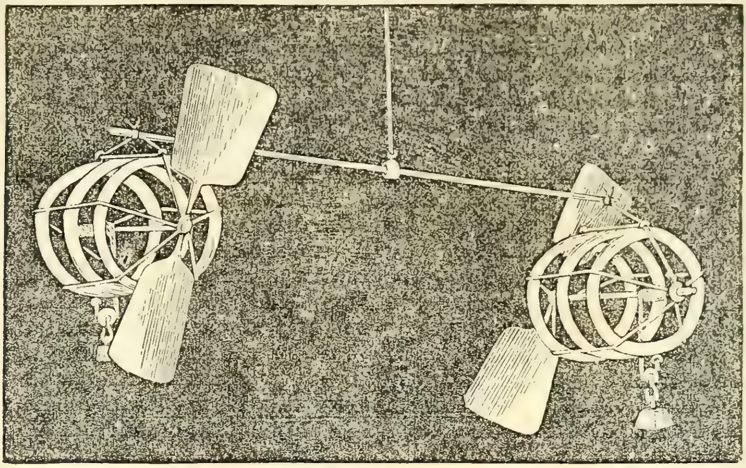
A difficult problem remains for solution; that of the *orientation* of the machine. M. Foselli attempted only to discover some practical way of determining the point above which the aeronaut is floating. He succeeded in his attempt on the 26th of December; and on that day he communicated his method to M. Dumas, Secretary of the Academy of Sciences, and to myself; but it was at that time absolutely necessary that it should remain a secret.

The method consists in drawing diagonals corresponding to the 4 cardinal points upon the 4 faces of a sufficient number of towers or upon the roofs of churches, with large conspicuous letters, so that they may not escape the notice of the aeronaut provided with a field glass. Besides this, should be printed the name of the place.

By this means the aeronaut will know his place and the direction in which he is going ; again, knowing the time and distance between two places, he can approximately determine the velocity of his balloon. This method is ingenious and the only one sure to indicate to him his course through the sky. In presenting his project and plan to the Academy of Sciences, M. Foselli had but one end in view; that of paying to France, the country of his adoption, the debt of gratitude for the immense service rendered his native land, Venetia, in delivering it from a foreign yoke. "I would buy," said he, "with my blood, the honor and good fortune to aid in the deliverance of Paris and France. Let my efforts be taken as tokens of my devotion."

He had constructed a model of his machine of sufficient scale to resolve a great number of problems relative to progression in the air; and he is certain that in a very calm atmosphere, a motive force relatively feeble, like that of the hand of a man acting upon a screw of small diameter, could move a load of several hundred kilograms supported by the aerostat. Besides, he has discovered an unexpected fact which may lead to the means of navigating against the wind, or force the wind itself to give the machine a motion different from its own. He had suspended his model and had fixed to it two screws of like form and dimension, but mounted so as to act in opposite directions. These were set in motion by the descent of a weight. Who would not have supposed

that under the action of these two screws, opposite in direction, equal and of contrary signs, the apparatus would have remained at rest? Yet it moved with a velocity greater than that due to the action of a single screw. These curious



results suggested to M. Foselli the happy thought of converting his model into an instrument (of which a figure is given above) by means of which one can illustrate a great number of phenomena relative to the motion of bodies in fluids and gases.

SOLAR HEAT—ITS INFLUENCE ON THE EARTH'S ROTARY VELOCITY.

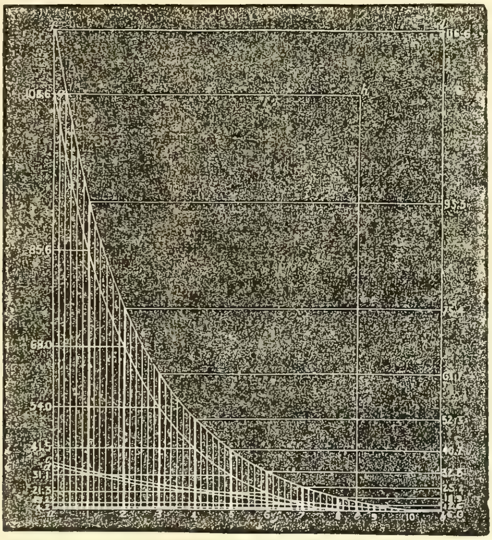
By CAPTAIN JOHN ERICSSON.

(*Continued from page* 565.)

Illustrations and descriptions have been prepared explanatory of important modifications of the dynamic register described in the preceding article adopted in order to control the irregular resistance of the atmospheric air against the rotating sphere, unavoidable in employing gas-flames for heating the equatorial belt; ut the subject having already occupied ore space than intended, I now propose state only the result of the experiments hich have been made with the modified instrument, the dimensions of which, it should be observed, have been considerably increased; the motive power, however, remaining unchanged. It is scarcely necessary to remark, that a complete demonstration and record of an investigation of this complicated nature would present an array of figures inadmissible in these columns. The accompanying diagram has, therefore, been devised to dispense with figures; the relations of time, velocity, and resistance, being presented in such a manner that, among other facts, the amount of mechanical energy which disappears during the experiment, may be ascertained by mere inspection. For the purpose of saving space and facilitating direct comparison, this diagram has moreover been so arranged that the record of the experiments in which heat and refrigeration have been employed, is placed on the same base line with the record of the experiments in which difference of temperature was prevented. The divisions on the base line, *a b*, mark the time of rotation, the large spaces indicating minutes and the smaller divisions 10 sec. each. The length of the ordinates of the curve, *c b*, resting on the base line, represents the number of turns performed in a given time when the rotating sphere is not subjected to the action of heat and refrigeration; while the length of the ordinates of the curve, *d e*, represents the

number of turns when heat and cold are being applied. It will be readily perceived that, for instance, the ordinate between l and the curve, $c\ b$, represents the number of turns per minute at the commencement of the second minute, while the ordinate 2 represents the number of turns per minute at the commencement of the third minute, and so on for all the other ordinates.

The *permanent* friction of the instrument, *i. e.*, the friction of the pivot on which the sphere turns, being practically inappreciable, it will be evident that the resistance opposing the rotation will vary in the ratio of the square of the velocities. Hence, as the respective ordinates between the curves, $c\ b$, and $d\ e$, and the base line, represent the *velocities*, it will only be necessary to square these ordinates in order to determine the exact amount of resistance to the periods indicated by the divisions on the base. Accordingly, the ordinates mentioned have been prolonged in the ratio of their squares, the curves, $f\ b$ and $g\ e$, being the result of this prolongation. Obviously, the lengths of the ordinates of these curves resting on the line, $a\ b$, represent accurately the amount of resistance opposed to the rotation of the sphere at the times indicated by their intersection with that line. The rate of velocity, *i. e.*, the number of turns per minute, performed by the sphere at the commencement and at the termination of each minute, will be found by referring to the figures marked on the vertical lines, $f\ a$ and $l\ b$. Thus, for instance the rate of velocity at the termination of the seco d minute is 75.4 turns, when refrigeration is *not* applied; while the rate is 68.0 when the cooling medium is applied at the pole. As might be expected from the irregular nature of the external resistance opposed to the rotating mass, the curves, $f\ b$ and $g\ e$, do not correspond with any of the conic sections. The available motive power of 2,540 foot-grains *expended* during the experiment, is represented by the superficies, $f\ a\ b$; the energy *developed* being represented by the superficies, $g\ a\ e$. Assuming the former to be 1.000 the latter as shown by our diagram will be 0.763, difference=0.237; hence the amount of lost energy is 0.237 $\times$2540=601.98 foot-grains. Now if the weight of water which is condensed at the pole and returned to the equator, multiplied by the height necessary to generate the rotary velocity acquired during the transit, should amount to 601·98 foot-grains, the fact will be established that the current of vapor has not, during its passage from the equator to the pole, restored any of the energy abstracted from the sphere by the current of water flowing in the contrary direction. The quantity of water condensed and returned to the equatorial belt being readily ascertained by observing the increment of temperature of the con-



tents of the polar cistern, it is easy to show that the energy abstracted from the rotating mass by the water thus transferred from the pole to the equator, corresponds so nearly with the differential mechanical energy represented by the superficies, *f g e b*, that the compensation resulting from the tangential force exerted by the particles of the currents of vapor against the surface of the sphere of the dynamic register, is practically inappreciable; precisely as we find that the compensating tangential force of the currents of vapor which sweep over the basin of the Mississippi from west to east (neutralized by the currents which pass from east to west) is an inappreciable fraction of the retarding energy of 19,336,000,000 foot-pounds per second, exerted by the *water* which the Mississippi carries in the direction of the equator.

Having thus analyzed the opposing energies called forth by the waters flowing towards the equator, and of the returning vapors, the condensation of which replenishes the river basins, we may now enter on a computation of the aggregate amount of the retarding energy, and the consequent diminution of the rotary velocity of the earth, caused by the rivers enumerated in the Table accompanying a previous article. The total of the retarding force entered in the last column of that Table, it will be found, amounts to 53,857,788,300 foot-pounds, per sec., which sum multiplied by 86,400 sec., shows that the earth has to overcome a resistance of $4{,}653{,}313\times10^{9}$ foot-pounds during each revolution. Multiplying this resistance by 36,524 days, we ascertain that the retarding energy of the water transferred in the direction of the equator by the entire Southern river systems of both hemispheres, amounts to $16{,}995{,}760{,}069\times10^{10}$ foot-pounds in a century. Now, in order to determine the diminution of rotary velocity consequent on this counteracting energy, it will be indispensable to compute the earth's rotary vis viva. The elements necessary in this computation are, volume, time of revolution, specific gravity, and the position of the centre of gyration of the rotating mass. The two first-named elements are known with desirable accuracy; the third element, specific gravity, has been ascertained with tolerable accuracy; but the position of the centre of gyration, which depends on the internal temperature of the globe and the disposition of its constituent parts, has not yet been determined. Physicists assume that the density of the globe increases towards the centre in arithmetical progression; but this assumption is not sustained by sound reasoning. Our space not admitting of discussing this complicated question at length, let us merely consider the leading fact, that, at a distance of only $\frac{1}{20}$ of the earth's radius=1,044,400 ft. from the surface, the weight of a superincumbent mass of fused granite, will exceed 900,000 lbs. to the sq. in.=60,000 atmospheres. Under this pressure the weight of air will be 70 times that of water, and 3.5 times that of the heaviest metals. Gold, at the point of fusion, is 7 times heavier than fused granite, while neither of these solids loses more than $\frac{3}{100}$ of specific gravity at melting heat; a fact which proves conclusively that high temperature of metals and minerals is not incompatible with great density. Hence, fused granite, in the earth's interior, may be many times heavier than the cold mineral at the surface. Unless, therefore, we are prepared to dispute the assumption that fused granite under a pressure of 900,000 lbs. to the sq. in. will have its specific gravity doubled—involving a density less than one-third of fused gold not subjected to compression—we must admit that the specific gravity of the earth at the depth of $\frac{1}{20}$ of the radius, is so great that, if the density, as physicists have assumed, increases in arithmetical progression towards the centre, our planet would be many times heavier than it is. We are compelled, therefore, to reject the accepted theory; more especially as the stated enormous pressure consequent on superincumbent weight, takes place at only $\frac{1}{20}$ of the earth's radius below the surface.

In accordance with the foregoing reasoning, our computation of the earth's rotary vis viva will be based on the assumption that the mass is *homogeneous.* It is true that the specific gravity at the surface is somewhat less than one-half that of the entire mass; but we have shown that at a depth of $\frac{1}{20}$ of the radius from the surface, the density is so great that if it continued to augment in arithmetical progression, the specific gravity of the globe would far exceed that which has been determined by careful investigation.

Nor should we lose sight of the important fact, that the temperature corresponding with the compression produced by the superincumbent weight, is so great that the component parts of the central mass may be as light as pumice, notwithstanding the enormous external pressure. Consequently, it may be satisfactorily demonstrated that the earth's circle of gyration extends considerably *beyond*, in place of being within that of a *homogeneous* sphere, agreeably to the accepted theory of augmented density towards the centre. In our computations, however, we will assume that the circle of gyration is that corresponding with homogeneity, which, in accordance with the property of spheres, is 0.6326 of the great circle. Sir John Herschel's determination shows that the mean diameter of the earth considered as a perfect sphere is 7912.41 statute miles, or 41,777,524 ft.; hence if we assume the specific gravity to be 5.5 we can readily calculate that the weight is $1,308,608 \times 10^{19}$ lbs. Multiplying the equatorial velocity, 1519.07 ft. per second, by 0.6325, we ascertain that the mean rotary velocity of the entire mass of the earth is 960.81 ft. per second; a rate acquired by a fall of 14,424 ft. The earth's rotary vis viva will accordingly amount to $14{,}424 \times 1{,}308{,}608 \times 10^{19} = 18{,}875{,}361 \times 10^{22}$ foot-pounds. The mind being utterly incapable of conceiving this stupendous energy without comparison with mechanical energies of less magnitude, let us ascertain to what extent it will be diminished by the retardation exhibited in the Tables previously presented, namely, $16{,}995{,}760{,}069 \times 10^{10}$ foot-pounds, exerted in the course of a century by the southern river systems of both hemispheres. Dividing the stated retarding energy in the earth's vis viva, thus: $\frac{18{,}875{,}361 \times 10^{22}}{16{,}995{,}760{,}069 \times 10^{10}}$, we find that notwithstanding the enormous amount of retardation exerted in a century only $\frac{1}{1110600000}$ of the rotary energy of the earth will be destroyed in that time. And if we multiply the fraction thus presented, by 10,000, we learn that at the end of 1,000,000 years, the rotary energy of the earth will be only $\frac{1}{111060}$ less than at present! By no other comparison, probably, than the one we have instituted, could we clearly comprehend the magnitude of $18{,}875, 361 \times 10^{22}$ foot-pounds of mechanical energy.

Let us now calculate the effect of the tabulated resistance, on the earth's rotary velocity, with reference to *time*. The retardation observed by astronomers being as before stated, about 12 sec. in a century, our object will be to ascertain how far this retardation may be attributed to the counteracting energy under consideration. Multiplying, then, the number of seconds in a century, 3,155,673,600 by the retarding energy of 53,857,780,300 foot-pounds per second, entered in the Table, we establish the fact before adverted to, that the total retardation is $16{,}995{,}760{,}069 \times 10^{10}$ foot-pounds in one century. Dividing this retardation in the vis viva, it will be seen that the earth loses $\frac{1}{1110592343}$ of its rotary energy in the course of 100 years; but in calculating the *time* corresponding with this loss, we have to consider that the velocities are as the square root of the forces, and that, consequently, the rotary velocity will not be reduced as rapidly as the rotary energy. Evidently, if the diminution of energy and velocity corresponded exactly, the retardation of the earth's rotary motion during one century would be $\frac{3{,}155{,}673{,}600}{1{,}110{,}592{,}343} = 2.8414$ sec. But in accordance with the laws of motion referred to, the diminution of velocity during the century, will be in the ratio of the square roots of the earth's vis viva at the beginning and at the termination of that period. Now this ratio being readily computed, as we know the amount of energy lost in one century while the time in seconds is also known, we are enabled to show by an easy calculation that the earth suffers a retardation of 1.42071 sec. Adding the retardation occasioned by the tabulated sedimentary matter=0.00105 sec. ascertained in the manner explained, the total retardation of the earth's rotary velocity in a century, at the *present* epoch, will be 1.42176 sec. The vastness of the rotary vis viva of the earth having already been discussed, it will not be necessary to offer any explanations with reference to the insignificance of the stated retardation, in comparison with the magnitude of the counteracting energy exerted by the water and sediment of the entire river system presented in our Tables.

We have now to consider the influence on the earth's rotary energy exercised by rivers, the course of which is in the direc-

tion of the poles. Evidently river water running *from* the equator, will have its motion round the axis of rotation, continually diminished as it reaches the northern parallels ; hence rotary energy will be imparted to the earth by all rivers flowing towards the poles. At first sight, it will be imagined that the energy thus imparted will neutralize the retarding force exerted by the waters transferred towards the equator. Certain physical causes, however, prevent the imparted energy from restoring any of the earth's lost vis viva. The subject will be most readily comprehended by an examination of the nature of the neutralizing force exerted by the following great rivers, namely, the Lena, Yenesei, Obi, and Mackenzie, which furnish the principal amount of water discharged into the Arctic Ocean. These rivers drain an area of 3,840,000 sq. miles, the latitude of the centre of their basins, and their outlets, being very nearly in the same parallel. The mean of the former is 59 deg. 30 min., that of the latter 69 deg. 56 min. Accordingly the mean circumferential velocity of outlet is 421.18 ft. per second, while that of the centre of basin is 770.95 ft. per second. It will be seen, therefore, that a diminution of rotary velocity of 770.95 — 521.18=249.77, say 250 ft. per second, takes place during the transfer of the water from the centre of the basins of these rivers to their outlets. Now a velocity of 250 ft. per second is produced by a fall of 976.5 ft., hence each *pound* of water discharged into the Arctic Ocean by the before-named rivers, will impart a mechanical energy of 976.5 foot-pounds. Apart from this powerful neutralizing force of a given weight, the quantity of water transferred is so great owing to the vast extent of the basins, that, notwithstanding the moderate precipitation in high latitudes, the rotary energy imparted to the earth will balance the retardation of the 136 rivers entered in our tables. It scarcely requires explanation that the stated enormous force exerted by the water transferred by the great northern rivers, is owing to the rapid diminution of rotary velocity in approaching the pole ; a single degree of latitude at the point where, for instance, the river Lena discharges into the Arctic sea, having a greater fall than *ten* degrees have within the tropics. It would be waste of time, however, to compute the exact amount of energy imparted to the earth by the Arctic rivers, as will be seen by the following examination of the subject. Unquestionably, if the supposed pound of water on entering the Arctic Ocean at once evaporates and ascends into the atmosphere, we must admit that an impulse of 976.5 foot-pounds has been imparted to the earth by its transfer from the centre of the river basin; but, if it should be found that in place of evaporating on entering the cold polar sea, the pound of water commences a retrograde motion towards the equator through Behring's Straits or through the wide channel between Norway and Greenland; and if we should find also that when it crosses the 59 deg. 30 min. parallel (the same as that of the centre of the river basin) it has not yet been converted into vapor, we must then admit that the whole of the energy imparted to the earth by the *approach* towards the axis of rotation, during the original transfer to the polar sea, has been completely neutralized by the retardation consequent on the *retreat* from the axis of rotation, during the southerly course to the last-mentioned latitude. Following our pound of water during the continuation of the motion towards the equator, we may discover that it has not changed its form into vapor even when reaching latitude 47 deg. 45 min., at which point the circumferential velocity is exactly 250 ft. per second greater than that of the centre of the basin from whence the motion proceeded. In that case, not only has the imparted energy been neutralized, but a *retardation* of 976.5 foot-pounds has been called forth by the pound of water, the course of which may possibly continue until it mixes with the warm water within the tropics. Let us guard against confounding the movement of the water discharged into the Arctic sea by the northern rivers, with the currents produced by the combined influence of lunar attraction, winds, differential oceanic temperature, and solar attraction. It has long been recognized that the water poured into the Arctic sea by the great Asiatic rivers, is the result of condensation of vapors raised by the sun within, or near, the tropics. A corresponding amount of water must, therefore, be returned from the polar sea, or its surface would be elevated, and that of the tropic-

al seas suffer a proportionate depression. The reader cannot fail to perceive the important bearing of these facts on the question of retardation of the earth's rotary velocity.

The result of the experiments with the dynamic register proves that the rotary motion possessed by the vapors on leaving the equatorial seas, may be almost entirely destroyed by being converted into heat during their course towards the basins of the northern rivers ; hence imparting no perceptible tangential force to the earth. Accordingly, the return to the tropical seas of the water which is continually being discharged by the northern rivers into the polar seas, will, on account of the increased velocity round the axis of rotation imparted during the southern course, subject the earth to an amount of retardation far exceeding that produced by rivers flowing towards the equator. It may be asked under these circumstances, why the latter rivers have been tabulated, and their inferior retarding energy calculated. The rivers flowing in the direction of the poles have been examined, tabulated, and their counteracting energy calculated ; but the question of attendant retardation of rotary velocity cannot properly be entertained until certain other counteracting influences shall have been examined. The publication of the Table containing the southern rivers has been deemed necessary as a *point d'appui* facilitating demonstrations intended to establish the fact that, independently of the counteracting force of the tidal wave (hitherto greatly overestimated), the retarding energy called forth by the evaporation within the tropics, and the consequent condensation and precipitation in the temperate zones, fully account for the retardation of the earth's rotary velocity—12 seconds in a century—inferred from the apparent acceleration of the moon's mean motion.

P. S.—Referring to the solar pyrometer, some misapprehension appears to exist concerning the indication of the focal thermometer. It is asserted that the loss of heat and consequent reduction of the temperature indicated by the focal thermometer, cannot, as assumed in our demonstrations, lead to an overestimation of solar intensity. A moment's reflection, however, will show that, agreeable to the adopted mode of computing solar intensity, *increase* of the temperature which is imparted to the focal thermometer by a radiator of given intensity will cause corresponding reduction of the deduced solar intensity. It was demonstrated in the article relating to the concave spherical radiator, that the sun, notwithstanding its size, is not capable, owing to the vast distance, of transmitting to the earth more than $\frac{1}{3610}$ of the temperature which the incandescent radiator transmits to its focus, equal intensity of radiant heat being assumed. Hence, it was inferred that the temperature of the sun must be 3,619 times higher than that of the radiator in order to transmit to the boundary of the earth's atmosphere as high a temperature as that transmitted by the radiator to the focal thermometer, viz., 117.2 deg. But the temperature produced by the sun's radiant heat at the said boundary being only 84.84 deg., it was shown that the radiant power need not be more than $\frac{3619 \times 84.84}{117.2} = 2619.76$ times greater than that of the incandescent radiator, in order to produce a temperature of 84.84 at the atmospheric boundary. The temperature of the radiator during the trial of February 4, 1871, was 1699.39° ; consequently $2619.76 \times 1699.37° = 4,451,941°$ is the solar intensity deduced from a differential focal temperature of 117.2 deg. Fahr. The *actual* temperature, however, transmitted to the thermometer placed in the focus of the incandescent radiator, during the trial referred to, was, it will be seen by reference to the Table, 157.83 deg. Now, comparisons with experiments conducted in vacuo, have shown that when the heat transmitted by radiation reaches 160 deg., in an atmosphere of 40 deg., the loss occasioned by exposing the thermometer to the surrounding air will be fully 0.06 or 11 deg. This great reduction of temperature is caused by the feeble energy of radiant heat compared with the powerful refrigeration produced by currents of air. We have accordingly to substitute $117.2° + 11° = 128.2°$, for 117.2° focal differential temperature. Agreeable to the assertion the correctness of which we are going to disprove, the increase of focal temperature ought to show an *increase* of solar intensity. That the converse will result from increased focal heat will be indisputably established by simply repeating

the foregoing calculation, substituting the focal temperature 128.2 for that of 117.2°. Thus $\frac{3619 \times 84.84}{128.2°} = 2394.97$ times greater temperature of the sun than that of the radiator—1699.37° Fahr.—will be required to cause an elevation of temperature of 84.84 on the Fahrenheit scale, at the boundary of the atmosphere. Basing our computation on the stated *high* focal temperature, we accordingly *reduce* the sun's temperature from 4,451,941°, to $1699.37° \times 2394.97 = 4{,}069{,}940°$. The fallacy of the assertion that diminution of focal heat cannot lead to an over-estimation of solar intensity, has thus been fully proved. At the same time we have shown that when due allowance is made for loss of focal heat, the solar temperature deduced from the indication of the incandescent radiator, corresponds very nearly with the temperature deduced from the indications of the solar pyrometer, viz., 4,063,984° Fahr.

ASTRONOMICAL OBSERVATION.

From "Nature."

The statistics of modern astronomical observation would, we suspect, be very curious, if it were possible to get at them. A report showing the gradual increase in the number of telescopes manufactured during the last fifty years would be very interesting; and so would be a table comprising at once the advance in their dimensions and the diminution in their cost. The result would, we believe, be such as at first sight to cause great surprise among those unacquainted with the subject, or those whose recollection does not go back to days when five inches was as extraordinary an aperture for an object-glass, as double that size is now. But the value of these, as of other tabular statistics, would suffer material abatement, if they were applied to establish any other conclusions than those to which they directly lead. For instance they would probably be fallacious, if considered as inferring a proportionate increase in the number of important observations. In order to bring out such a result, we require, so to speak, another factor, and a very essential one—a corresponding increase in the number of competent observers. This, we fear, may not have been commensurate with the advance of optical means; at least, except upon the supposition of some such deficiency, it is difficult to understand what becomes of the multitude of really good object-glasses which are annually produced, not only in England, but in Germany and America. A large proportion of these, we are led to think, must be purchased to be looked at, and not looked through, or handled as mere toys for the amusement of people who do not know what to do with themselves in an idle evening. This was not so much the case in the early days of telescope manufacture. The greatest master of figuring specula in his own time was also the greatest proficient in using them; it is needless to add the name of Sir William Herschel. And so the fine reflectors in Germany were placed at the same period in the hands of the leader of all accurate selenographical investigations, J. H. Schröter. These were "the right men in the right place." Even then, it may be said, many noble reflectors went, no one knows where, the greater part of them long before this time useless from tarnish, or, still more mortifying to think upon, ruined by unskilful repolishing. Still, admitting this, the disappearance of powerful instruments does not seem to have been so remarkable in those days as it is now, and the quantity of really valuable observations appears to have been greater in the end of the last and the early part of the present century, in proportion to the means of observing.

This is not a very encouraging view of the present state of this branch of astronomy. But, if well founded, as we believe it to be, we might expect that there would be some assignable reasons for it; and, in fact, several are sufficiently obvious. One certainly is, that the process of discovery is not, generally speaking, renewable. What has been once detected is usually placed on record, in bar of all future claims. So it has been in the science of music; a man might arise among us with the fervid genius of Handel, but he could not write the Halle-

lujah Chorus over again; and doubtless the spirit of Mendelssohn must have been cramped by the impossibility of employing many of the noblest and most impressive subjects which had been anticipated by his predecessors. And so it has been in the researches of geography. The enterprising explorer has now to go much farther in pursuit of "fresh woods and pastures new," and every Alpine season is so rapidly narrowing the number of summits untrodden by the foot of man, that the excitement of a first ascent will soon have to be sought in remoter regions. Thus in astronomy, though it cannot be said that there are no worlds left to conquer, yet all the larger and more conspicuous features of the heavenly bodies have been long ago so fully noted and recorded, that what remains for exploration is chiefly of that delicate character which, without being the less interesting from its minuteness, is less accessible, for that reason, to the possessors of ordinary instruments. And on this account many a student who might well have risen from the ranks in the earlier days of scientific campaigning, is now compelled to remain in comparative obscurity—a mere spectator, when he might well have taken his place among the discoverers of fifty years ago.

Another reason why tools have multiplied without a corresponding increase of good work, may be this, that looking upon the observer and his instrument as a complex apparatus, the improvement of the intelligent has not kept pace with that of the material part. In fact, it is impossible that it should. The eye is but what it was when David learned humility from considering God's heavens, the work of His fingers, the moon and the stars, which He hath ordained; the intellect, though more developed and cultivated, is not more strong and piercing than it was in the days of Hipparchus; man does much more with his brain, but he has no more brain to do it with, than his uncivilized ancestors; and observers may, and will, be collectively multiplied without being individually improved. Every man that has eyes does not know how to use them; or, not failing in this respect, he may lack other requisites: he may not know what to look for, or where to find it; or he may be deficient in his handling of the faithful pencil or the expressive pen. And so it comes to pass that the capacities of instruments may be much in advance of the abilities of those who use them.

Besides all this, there is a physical obstacle of an entirely different character, which must not be forgotten,—the unimprovable constitution of our own atmosphere. This will ever be a sore subject for the zealous observer, especially among ourselves. If even Secchi finds fault with the glorious Roman heavens, what have we not to regret in our own murky, and fuzzy, and restless skies? Who that has read the most graphic as well as instructive writings of Sir J. Herschel is likely to forget his complaints of "twitching, twirling, wrinkling, and horrible moulding?" and who that has had much actual experience of observatory work will not endorse all this with a very lively fellow-feeling? The nights may easily be numbered, during a long season, in which the defects of the atmosphere do not overlie those of the instrument, and when the observer has not rather to wish that he could see all that his telescope could show him, than to long for greater power or light, to be expended in making atmospheric disturbances yet more conspicuous and prejudicial. The only way to obviate this grievous hindrance is to get above it; and no man has yet done this except Professor Piazzi Smyth in his most successful "Experiment;" it was said, indeed, that the French observers were about to follow his example and to plant their instruments on the Pic du Midi de Bigorre; but we have never heard whether the idea has been carried into execution. And, however striking may be the advantage of such a plan, it must ever be confined to a favored few.

We have dwelt at some length on a view of the present state of astronomical observation, which, though rather unfavorable, we believe to be substantially true. But it is not to be inferred that this is its sole aspect. There are, as usual, two sides to the shield; and much is to be said that is of an opposite tendency. If, for instance, we have asserted that for some time past observers have not multiplied in proportion to the means of observation, this is but a relative statement; the absolute fact is that at no former period has there been so numerous, or so zealous, or on the whole so competent a band of astronomical students. And of

this we have a very pleasing evidence in the recent formation of an astronomical society expressly devoted to physical observation, to which we cordially wish success. If, again, it is probable that not many of the great discoveries are left within the reach of ordinary instruments, it should not be forgotten that many telescopes of very superior character are now housed in private observatories; and that for them investigations are still reserved, whose delicacy is no bar to their importance, and which may be undertaken with a hope of success no longer chargeable with extravagance. Great cabinets may be unlocked by little keys. Minute researches may give the clue to discoveries of the broadest extent and deepest interest. The changes of the lunar surface; the internal motion of starry clusters; the parallax and fixity of nebulæ; the planetary attendants on the brightest stars, these are mere specimens of the magnificent arcana, whose solution may not be denied to human energy and perseverance. We may, remember, too, that if the telescope and the micromoter should be found unequal to the task, we have yet a new and most powerful method of investigation, the results of which are equally important and surprising—spectrum-analysis. The revelations of this beautiful invention may be said to be only beginning, and no man can foresee their end. What has already been done would have appeared as improbable as the reveries of Kepler, had it been predicted 50 years ago; and who shall say what may be the result of 50 years more of patient and energetic application? And what might not Kepler have said and done, had such an instrument of research been placed in his hands? We may suppose how his fervid imagination would have exulted in the prospects, and with what confident joy he would have repeated the memorable words which characterize one of his lofty aspirations, "Plus ultra est."

The Weston Patent Smoke and Gas Consuming Boiler Company.—This is the name of a new corporation formed to introduce the above-named boiler to the attention of railroad and steamship managers, engineers, master mechanics, and, in fact, to all using steam power. It is claimed for this invention that it will save $\frac{1}{3}$ the fuel used in the generation of steam, besides completely consuming all smoke and gas—facts which are vouched for by the South Side Railway Company of L. I.; the Grant Locomotive Works, Paterson, N. J.; by H. Anderson, late General Master Mechanic of the Chicago and North-Western R.R. Company; the Superintendent of the Vulcan Iron Works, Buffalo, and several other prominent establishments where this boiler has been thoroughly tested and in successful operation during a year past.

The annual product of pins in the United States is 2,000,000 packs, each pack containing 3,300 pins, or a total of 6,720,-000,000 of pins. This terrible quantity is the yield of 8 pin factories. One manufacturer's agent in Boston, according to the "Bulletin," sells every 6 months 1,000 cases of pins, each case containing 672,000 pins. The factory represented turns out 8 tons of pins per week. Hair pins are jobbed by the cask, and but one factory makes them, but that at the rate of 50 tons per month. The machine which cuts and bends the wire, makes 360 hair pins per min., ready for japanning. The production and consumption of pins increases 10 per cent. annually. A great part of the hair pins used are imported. After these figures, we can safely ask, What becomes of all the pins?—*Iron Age.*

What is Navigable Water?—A recent important decision of the United States Supreme Court establishes that a river is a navigable water of the United States when by itself or in connection with other waters it forms a continuous highway, over which commerce is or may be carried on with other States, or with foreign countries, in the customary modes in which such commerce is conducted by water. If a river is not of itself a highway by its connections with other water, and is only navigable between different places within the State, then the Court holds it is not a navigable river of the United States, but only a navigable water of the State. This is clear enough, and is worth making a note of.

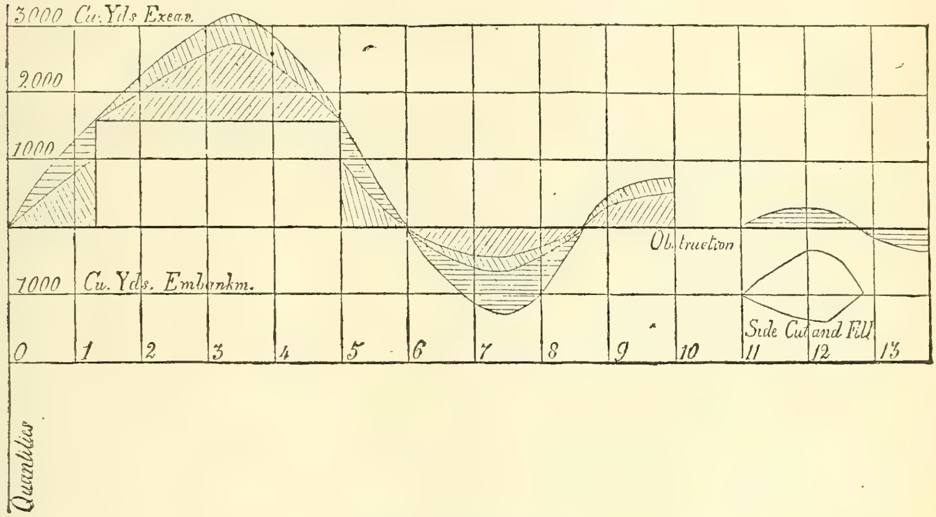
California has 2,307 miles of railway, and is far above some of the older States.

ON RECORDING EARTHWORK NOTES.

By H. KOCH, C. E.

Every railway engineer knows how important it is to have earthwork recorded in such a manner as to show, without calculation, what quantities either of embankment or excavation, whether of borrow or waste, lie between any two stations. We offer here a simple device to accomplish this end.

Represent the stations on an absciss line, the earthwork quantities by ordinates, commencing with 0 at station 0, and representing the quantity of earth-



Explanation of Engraving.

Total work to be done represented by outside curve.

From station 0 to 1, 1200 yds. cut.
" " 0 to 2, 2340 "
" " 0 to 3, 3000 "
" " 0 to 3 + 20, 3030 yds. cut.
At 3 + 20, beginning of fill.
From station 0 to 4, 2800 cb. yds. cut.
" " 0 to 5, 1420 " "
" " 0 to 5 + 90, 0" "
Between 0 and 5 + 90 cut and fill are equal.
Between 0 and 6 or 5+90 and 6, 200 cb. yds. fill.
5+90 and 7, 1180 " "
7+40, 1300" "
At 7+40 fill changes into cut.
Between 5+90 and 8, 1060 cb. yds. fill.
8 + 60, 0" " "
Between 5 + 90 and 8 + 60 cut and fill balance each other.
Between 8 + 60 and 9, 480 cb. yds. cut.
10, 650 " " "
This cut to be wasted on account of obstruction.
Between 11 and 12, 320 cb. yds. cut.
Between 11 and 12 + 95, 0 cb. yds. cut.
Betwen 12 + 95 and 14, 320 cb. yds. fill.
Between 11 and 12, 600 yds. side cut and 280 side fill.
Between 12 and 12 + 95, 600 yds. side fill and 280 side cut.
The work of two different months is represented by the proper curves.
On first month, between 1 + 35 and 4 + 90, 1100 cb. yds. cut, worked in to fill; 350 cb. yds. left to be done yet.
Between 5 + 90 and 8 + 60, 420 yds. cut, worked in to fill; 780 left undone.
Between 8 + 60 and 10, 450 cub. yds. cut wasted; 200 yds. left.
On second month 1000 cb. yds. are taken from cut between 0 and 1 + 35 to fill between 4 + 90 and 5 + 90; work between 1 + 35 and 4 + 90 completed; 600 cb. yds. cut and fill left undone between 0 and 5 + 90.
Between 5 + 90 and 8 + 60, 220 yds. are moved from cut to fill and 600 left undone..
Between 8 + 60 and 10 work completed with 200 yds. cut, wasted.

work between this and the next station by an ordinate at the latter. Excavation is to be represented by measurements upwards, or by an increase of ordinate, and embankment in the opposite direction.

If the extremities of the ordinates to a series of stations be connected by a curve line, the points where cut and fill balance will be shown by the intersection of the curve and the abscissa. The maximum points will show where cut changes to

fill, and the minimum where fill changes to cut. A break in the curve either above or below the absciss line, indicates the necessity of wasting or borrowing respectively at that point.

The scale for the whole may be made convenient to the amount of work.

The work of different months over the same line may be represented by curves of different colors or shades.

The labor of drawing the above is very slight; the curve may be drawn on the same sheet as the length profile.

The accompanying sketch of a record of an imaginary earthwork will serve to explain the plan more fully.

LITHOFRACTEUR.

From "Engineering."

Those of our readers who have followed us in our series of articles upon the subject of explosive compounds will be aware that we have many which possess great power for work, but which are unsafe to manipulate. They will also remember that the aim has been for some years past to tone down the violence of these compounds either by effecting new combinations of old materials, or by introducing new ones, so as to combine perfect safety in handling, transit and storage, with thorough efficiency in action. The principal practical results which have accrued have been the production of gun-cotton and dynamite, the use of the latter being confined to the Continent, chiefly on account of the existence in England of the Nitro-glycerine Act, which virtually prohibits the transport and storage of compounds into the composition of which nitro-glycerine enters. Within the last week, however, we have had to add another to our list of safe yet violent explosives tried in England, and which bears the name at the head of the present article. Lithofracteur—literally stone-breaker—is the patented invention of Professor Engels, of Cologne, and is composed of nitro-glycerine as a base, gun-cotton, the constituents of gunpowder, some chlorates, and an infusorial earth. These substances are prepared in a special way, and blended together by special means, the details of these operations being known only to the inventor and the manufacturers, Messrs. Gerbrûder, Krebs & Co., of Cologne. The result of this combination is a black compound of the consistence of soft putty, which is made up into paper cartridges $4\frac{1}{2}$ in. long by $\frac{7}{8}$ths of an inch in diameter, and weighing $1\frac{3}{4}$ oz. each. When lighted in the air by ordinary means it simply burns out, leaving a light white powder as a residuum; but when it is ignited either in the air or in a closed chamber with a capped fuse, its full violence is developed. It is safe under all ordinary and even extraordinary circumstances of storage and transit, as recent experiments in England and lengthened use on the Continent have proved. And here we may mention that, although this is almost the first time we in England have heard of this substance, it has been made and extensively used throughout Germany for more than two years past. It was used by the Prussians against the French during the recent war, Herr Engels being the operator. After Fort Issy was taken the Prussians destroyed a number of French heavy siege guns by blowing off their muzzles with lithofracteur.

A notice of this material having appeared in the German papers, the attention of the mining world in England was attracted to it, and a correspondence ensued between the manufacturer and Mr. R. S. France, the lessee of some extensive quarries in England. The result was that arrangements were made for testing the new material, Mr. France offering the use of his quarries, and Messrs. Krebs carrying out the experiments. In order that full publicity might be given to the trials Messrs. Krebs invited the attendance of a number of scientific gentlemen, who met at Paddington on Monday morning last, and proceeded to Shrewsbury, near which town Mr. France's quarries are situated. The party consisted of Captain Harvey, R.N., the inventor of the torpedo bearing his name, Captain McEvoy, of the London Ordnance Works, Mr. Brown, of the chemical department at Woolwich Arsenal, who represented the Government upon the occasion, Mr. Cargill, C.E., and Messrs. Houlder, Hockin, Comyn,

and Farrell, gentlemen connected with mines at home and abroad. The experiments were conducted by Herr Engels, assisted by Mr. Perry, F. Nursey, C.E., who is the engineer, in England, to Messrs. Krebs & Co., the arrangements of the trip being excellently carried out by Mr. Kirkmann, of Cologne, on behalf of Messrs. Krebs. The experiments were commenced on Tuesday morning at the Nant Mawr quarries, which are about 23 miles from Shrewsbury. These quarries are being worked in a range of carboniferous limestone mountains extending from 20 miles to the west of Shrewsbury northwards to the coast. The workings are approached from the railway by a double tramway 500 yards long, laid at a gradient of 1 in 8 up to the summit. Here the 2 lines branch off into 15, running to the face of the work. The wagons of limestone are sent down the incline by gravitation, the full trucks bringing up the empties. The limestone is of a very fine character, and is much used in iron works as a flux, the top portion being burnt for lime, Mr. France having 16 kilns for that purpose, which he keeps well employed.

The preliminary experiment consisted in throwing a box containing 5 lbs. of lithofracteur from the top of the quarries at a height of a 150 ft. from the ground into the plateau below. The box was smashed and the cartridges were scattered about, but not one was exploded. A cartridge was then lighted by an ordinary fusee, when it burned slowly out. Another cartridge was then placed upon a block of stone and fired with a percussion fuse, when a violent report followed, and the top face of the stone was broken off. The power of the lithofracteur when confined was then exhibited by firing charges in the bore-holes of several blocks of stone, which were shattered into many fragments. The tamping in all cases was effected with water, thus proving the usefulness and reliableness of the compound in workings where wet ground was met with. Another point also proved was, that if a misfire should occur—and one or two did occur in the course of the experiments—the charge could be withdrawn—and another one inserted without removing the tamping. And here we may explain that the method of firing is similar to that adopted by Nobel with dynamite and Abel with pulped gun-cotton. The capped fuse is simply imbedded in the lithofracteur, the paper of the cartridge being tightly tied round the fuse. The next part of the programme consisted in firing a number of shots, both horizontal and vertical, in the face of the quarry. As these were more or less repetitions of each other, we need only notice a few of them, although they all gave extraordinary results. The holes were mostly bored under the direction of some of the mining gentlemen present, who, with the view of testing the compound to the utmost, selected the worst possible spots, some of which, they stated, gunpowder would not possibly touch. The first of these blasts was made with a 1 lb. $1\frac{1}{2}$ oz. of lithofracteur placed in a horizontal bore hole 3 ft. 4 in. deep, and $1\frac{1}{2}$ in. in diameter. A large quantity of the stone was blown out to the front, and the face of the rock was scaled and cracked over an area of 20 ft. 6 in. wide by 13 ft. high. A couple more shots were then fired simultaneously near to the last, the bore-holes were each 3 ft. deep, and were charged with $13\frac{1}{2}$ oz. and 1 lb. $\frac{1}{2}$ oz. respectively, and an immense face of rock was brought down. The best blast, however, was the last of this series; it was fired in a vertical bore-hole, 4 ft. 6 in. deep, on a ledge of rock, about 23 ft. from the level of the plateau below, 1 lb. $1\frac{1}{2}$ oz. of lithofracteur being used. The explosion brought down at least 20 tons of rock, and loosened an enormous mass behind the bore-hole, the shot being one of the finest we ever saw with so small a quantity of material.

Some experiments were next made with the view of showing the disruptive effect of lithofracteur on iron, and for this purpose a 4 ft. length of 75 lbs. double-headed rail was laid on its side, being supported at each end at a height of 3 in. from the ground. A charge of 1 lb. 3 oz. of the compound was placed in a lump on the centre of the rail, and tamped with paper, three old sleepers being placed on the tamping, and fired with a percussion fuse. A startling report ensued, the fragments of the sleepers being sent in all directions, and on examination the rail was found much bent, and with one head cut through, and 11 in. of the web blown away in the centre. Had the supports been a little higher, so as to have left room for a greater angle of bend in the rail, both heads would doubtless have been cut

through. The experiment was then repeated with two similar lengths of rail to the last, placed one on the other on their sides, the charge being 1 lb. 5 oz. of lithofracteur. The under rail was 6 ft., and the upper piece 3 ft. 6 in. long, the height of the supports being increased to 1 ft. 6 in. Five pieces of old sleeper were placed over the charge, which, when fired, hurled them with a cloud of dust high into the air, scattering the débris far and wide. Both the rails were broken clean through, the halves being thrown far away from each other. The under rail was also cracked through both tables on one side.

So far, with the exception of one or two experiments at the first, the power only of the lithofracteur had been put to the test. It was now proposed to carry out an idea, which originated with Mr. France, to put the compound to the severest possible test in order to prove its behavior under the conditions of a railway collision. To this end he had an old railway wagon placed on the rails at the bottom of the incline, whilst at the top was another, in front of the buffers of which were fixed two cartridges, one on each buffer. Each wagon weighed about $1\frac{1}{2}$ tons, the buffers of both being of wood. The upper wagon being released, started on its journey of 500 yards on an incline of 1 in 8, the speed being of course very great when it reached the bottom. On arriving there the buffers fairly met, and both wagons were in a few seconds lying a heap of splinters and fragments, wood and iron being alike smashed up. On examining the wreck the lithofracteur was found smeared on the buffer heads and other parts of the wagons. No explosion having of course occurred. The possibility of an explosion in a collision, should two iron surfaces, or even an iron and a timber surface meet, was then suggested by Mr. Brown of the Royal Arsenal, and Mr. France, in a most spirited manner, ordered the experiment to be repeated, with the buffers of the upper wagon iron-plated. The iron-on-iron test was carried out by tying two cartridges on the top surface of each rail at a point about 50 ft. above the foot of the incline. Upon the upper wagon being released, it went on its way down the incline, but had only reached about half way when its high velocity caused a wheel to break, and the wagon went smashing and spinning over a steep embankment into the meadows below. No explosion occurrred here, but the party were unexpectedly gratified by witnessing the representation of another class of railway accident.

Nothing daunted, Mr. France ordered out another victim to scientific research, and a fifth wagon was doomed. The buffers were iron-plated, and the cartridges were fixed in front of them as before. When once started from the summit of the gradient it rushed downwards, passing in its course over the cartridges on the rails. Two semi-explosions occurred, such as would be produced by striking a percussion cap with a hammer on an anvil. When the descending wagon reached the stationary one it smashed into it, and they toppled over together, another slight explosion being heard. The buffer plates were found some feet from the line, with pieces of the cartridge paper and some of the lithofracteur adhering to them, portions also being spattered over other parts of the framing. On examining the rails the greater portion of the compound was found to have been spurted about, one of the cases remaining tied to the rail, and the other having been carried some yards down the line. The explosions were occasioned by the ignition of that portion of each cartridge exposed to the force of impact, the remainder not having been exploded nor burned. This is borne out by the fact that on one rail we found a smear of lithofracteur, 7 ft. 6 in. from the cartridge case, in the centre of which was a small white spot. A careful examination of this spot proved it to be exploded lithofracteur, and 7 ft. 6 in. being the exact circumference of the wheel at the tangent of its cone with the rail, there could be no doubt that the wheel had picked up a piece of the compound, and, on completing its next revolution, deposited it on the rail, an almost inappreciable portion exploding at the point of contact. These experiments concluded the day's proceedings, after which the party returned to their headquarters at Shoeburyness. The experiments were resumed on the following day at the Breidden quarries in a different kind of stone, and some submarine experiments were also carried out, but want of space obliges us to defer a notice of these until next week.

Mr. France's object in having these last

experiments made was to test the effects of concussion upon lithofracteur. He considered this essential, in order to meet the objections raised by railway companies to the transit of explosive compounds, and he deserves the thanks of all interested in mining matters for the convincing manner in which he has demonstrated the harmless character of lithofracteur. The great drawback in many cases at the present time to efficient mining and quarrying is the lack of such substances as these, which above all others are calculated to promote the development of this class of property. It is to be hoped that the stringency of the Nitro-glycerine Act will be somewhat relaxed, now that that dangerous substance has been proved to be so safe and harmless under all possible conditions except those of actual work.

THE RELATIVE VALUE OF DIFFERENT KINDS OF FUEL.

From the "Colliery Guardian."

The evolution of force by heat, with motion as a resultant, is one of the most important of the laws of natural philosophy. Wherever motion occurs, heat must be recognized as the primary cause. The sum is the original source in the production of heat, as shown by its influence upon tides, winds, and the support of the life of plants and animals. Its effect is curiously displayed on the natives of the tropics, in supplying them with such sustenance by natural heat as to make very little food requisite ; whilst towards the frigid zone, the use of carbonaceous food becomes more and more necessary. The elements hydrogen and carbon, in combination with oxygen, evolve a greater amount of heat than any other elements. As hydrogen is not attainable, substances such as wood, peat and coal, which contain a large proportion of carbon, are chosen as the materials which by combustion produce heat. In the construction and building up of organic life, a certain amount of energy is invested by the sun's rays. In combustion this energy re-appears as heat. This, in a few words, is the true theory of heat. The more a substance is capable of absorbing and rendering latent a certain number of units of heat, the more it is capable of giving out, when consumed with oxygen, appreciable and useful energy.

It is important to observe the comparative results available from what may be termed "current-going" heat, as developed by the work of a horse, and conserved heat, as shown in the work done by the combustion of fuel. This is demonstrated by the fact that the combustion of a single pound of coal in one minute is equal to the work of 300 horses for the same time. The extent to which any country is influenced by the possession of coal fields is evidenced by the following singular statement : Taking 10 lbs. of coal per day, or $1\frac{1}{2}$ tons per year, as applied to the production of mechanical power through the agency of steam, to be equal to the labor of a man, every 10,000,000 tons of coal adds to the productive labor of England, a force equal to the exertion of 7,500,000 fresh men annually. A beautiful example of nature's constant law of "no waste" is afforded in considering the combustion of fuel. The exact amount of carbon which is set free by combustion, either of fuel or animal life, is again stored up in animal vegetation. The results of combustion, viz., carbonic acid and water, return to the earth to support the life of plants and trees, which absorb the carbon from the carbonic acid, setting free the oxygen again for the support of life or combustion, and obtain hydrogen from the water in the atmosphere. Each element retains its calorific power, and thus the fuel of the future is undergoing a constant process of formation from the results of the combustion of the fuel of the present.

A brief description may now be given of the different varieties of fuel used in the British Islands.

Table I.

Name.	Where found.
1. Wood	
2. Charcoal	
3. Peat	Ireland and moorland districts.
4. Lignite	Germany and Devonshire.
5. Bituminous coal	All English coal fields.
6. Anthracite	Wales.
7. Coke	

I. Wood.—This is the original form of

fuel. The objections to its use are, first, the comparative small amount of carbon it contains, varying from 40 to 53 per cent.; second, the amount of moisture it generally contains—the value of damp wood being $\frac{1}{5}$ less than dry; third, the surplus of oxygen it contains, which retards combustion. Wood is only used as fuel when it is abundant and coal is scarce.

II. Charcoal.—Charcoal is wood freed from its volatile ingredients. Owing to the scarcity of wood and inconvenience of manufacture, charcoal is only used as fuel when coal is scarce, or when a hot fire is desired in small compass. It is more pure than coal, but absorbs moisture to the detriment of its heating power. The following is a scale of the comparative heating value of different woods before and after being made into charcoal, No. 1 being the best:

Table II.

	Wood.	Charcoal.
1.	Fir	Oak.
2.	Poplar	Birch.
3.	Birch	Poplar.
4.	Sycamore	Fir.
5.	Ash	Elm.
6.	Elm	Sycamore.
7.	Oak	Ash.

There is much more variety in the wood than in the charcoal, the former varying from 1,000 to 790, and the latter from 1,000 to 985.

III. Peat.—Peat, resulting from the decomposition of vegetable matter in marshes, has about $\frac{3}{4}$ the heating power of coal, and is used almost solely in the localities where it is found. It is difficult to obtain it free from earthy particles.

IV. Lignite.—This is an imperfect coal formed by wood buried in moist earth, and thus undergoing one of the changes leading towards the production of coal. It occurs rarely in the British Islands, but is used extensively in Prussia and Austria. It contains when found a large percentage of water, which is difficult to eliminate. It will be seen by Table IV. the extent to which the proportion of oxygen decreases in the change from wood to coal—lignite being the intermediate stage.

V. Bituminous Coal.—This is the most important fuel, and presents the varieties of splint, caking, open-burning, and cannel coals. These are the coals used for steam, gas, household purposes, and for iron smelting, in the form of coke or otherwise. The splint and coking coals form the chief produce of the northern counties. Splint is a caking coal with a dull appearance. The open-burning coal also bears the name of "cherry" and "soft coal." The difference between the caking and the open-burning coal is probably due to the larger proportion of bitumen in the former, and of oxygen in the latter. Cannel coal is most valuable for gas purposes, a maximum proportion of hydrogen, and a minimum proportion of oxygen, being required for this. This coal has probably been originally formed from the densest vegetation. Its conchoidal fracture, lustreless appearance, and cleanliness to touch, are well known properties. The following is a table, exhibiting the relative quantities of heat given off by the same weight of each of the varieties of bituminous coal, from experiments made by Dr. T. Richardson:

Table III.

Species of Coal.	Locality.	Relative quantity of heat given out by the same weight of coal. Edinburgh=100.00.
Splint	Newcastle	110.34
"	Glasgow	115.12
Cannel	Lancashire	117.83
"	Edinburgh	100.00
Cherry	Newcastle	116.68
"	Glasgow	112.12
Caking	Newcastle	122.12
"	Durham	114.98

VI. Anthracite.—The coals belonging to this class are characterized by containing a much larger amount of carbon than any other variety, and but very little volatile substance. This coal is generally found in regions distinguished by igneous action, as in Wales and the Alps, and is, probably, bituminous coal, altered by transmittent volcanic heat into a natural coke. In Wales, the same bed may be traced from where it is bituminous to where it is anthracite. The smokeless nature of this coal makes it of great value as a steam coal, there being so little gas, the setting free of which usually carries off a portion of carbon as smoke, to escape.

VII. Coke.—When coal is freed arti-

ficially from the volatile gases, coke, which when produced from good coal is nearly pure carbon, is the result. The process of making coke is also resorted to for the purpose of removing the sulphur from the coal, and for producing a strong compact fuel for iron smelting. The component parts of several well-known combustibles are shown in the following table, in which may be observed the chemical decomposition of wood in its gradual conversion to coal:

Table IV.

	Wood.	Peat.	Bovey Lignite.	Boghead Cannel.	Wigan Cannel.	Newcastle Caking Coal.	South Wales Anthracite.	Durham Coke.
Carbon	510	540	663	631	801	849	904	932
Hydrogen	53	52	56	89	55	45	33	7
Oxygen	417	282	229	70	81	67	30	9
Nitrogen	..	23	6	2	21	10	17	13
Sulphur	..	6	23	10	15	6	..	..
Ash	20	97	23	198	27	23	16	39
Total	1000	1000	1000	1000	1000	1000	1000	1000
Coke, per cent	213	293	308	302	604	750	921	..
Specific gravity	.81	.85	1.13	1.20	1.28	1.28	1.39	..

It will be seen from the above analyses that the proportion of hydrogen in fuel varies very slightly in passing from one condition to another, whilst the quantity of oxygen is very materially less as the process of coal formation progresses. This is the simple cause of the higher calorific power of coal as compared with wood and peat. The greater portion of the oxygen is set free by natural distillation, and hence carbon and hydrogen constitute a large proportion of the residue.

The following table (No. V.) shows an analysis of the different coal found in England and elsewhere.

Having now shown the chemical composition of the chief descriptions of fuel, it will be desirable, for the purpose of illustrating their distinctive value, to compare their calorific power, and that of their constituents. This is done in several ways in the following table (No. VI.), on referring to which it will be seen that hydrogen has by far the highest heating power; hence some coal has more capacity for generating heat than pure carbon. The whole of the hydrogen, however, is not utilized, since, when oxygen exists with hydrogen in any fuel, they form water in the act of combustion, and only the surplus is available.

Table V.

	Northumberland and Durham.			South Wales.		Derbyshire house and coking.	Scotland. Eglinton.	Lancashire. Ince Hall Arley.	Borneo.	Van Diemen's Land.	Trinidad.
	Best house.	Steam.	Coking.	Steam.	Anthracite.						
Carbon	843	787	868	807	923	799	801	826	703	802	652
Hydrogen	55	60	50	57	30	48	65	59	54	30	43
Oxygen	62	101	52	24	26	110	80	74	192	48	217
Nitrogen	21	24	10	13	6	12	16	18	7	14	13
Sulphur	12	15	9	44	..	7	14	8	12	19	7
Ash	7	13	11	55	15	24	24	15	32	87	68
Total	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Coke, per cent	750	606	721	751	921	578	549	640	...	...	....

The difference in value of the several samples of coal is interesting, and seems in favor of the Welsh and Newcastle coal, which are the only coals having a higher heating power than pure carbon. It will be observed that with the exception of the Derbyshire coal, the calorific power varies with the proportion of carbon. In the case of Derbyshire coal, the oxygen is in such such excess that it absorbs a a large portion of the hydrogen to form water. For the same reason, the heating

Table VI.

	Composition of Fuel.			Calorific Power.		Lbs. of water heated from the freezing point to 212° F. by 1 lb. fuel.	Lbs. of water at 212° F. converted into steam by 1 lb. fuel.
	Carbon.	Hydrogen.	Oyxgen.	Heat in degs. F. to which 1 lb. of water will be raised by 1 lb. of the fuel in conjunction with oxygen.	Relative.		
Hydrogen	...	1.00	...	62,032	4,265	344.6	62 6
Light carburetted hydrogen	.75	.25	...	23,513	1,816	146.7	26.7
Olefiant gas	.86	.14	...	21,344	1,466	118.5	21.5
Carbon burning to carbonic acid	1.00	...	...	14.544	1,000	80 8	14.7
Carbon burning to carbonic oxide	1 00	...	...	4,453	306	24.7	....
Carbonic Oxide	.43	...	.57	3,116	214	17.3	3.1
COAL:							
Average Welsh	.838	.048	.041	14,833	1,020	82 4	15 0
" Newcastle	.821	.053	.057	14,796	1,017	82.2	14.9
" Scotch	.785	.056	.097	14,150	973	78.6	14.3
" Derbyshire	.795	.049	.101	13,919	956	77.3	14.1
" Lancashire	.779	.053	.095	13,890	955	77 2	14.0
Coke	.94	.0004	.007	13,197	900	72 7	13.2
Peat, dry	.60	.06	.31	10,152	694	56 4	10.3
Wood, dry	.50	.06	.41	8,029	551	44.5	8 1
Phosphorus	...	...	...	13,500	929	75 0	13.66
Naphtha	...	...	...	13,208	909	73 2	13.4
Alcohol	...	...	...	12,931	889	71.8	13 1
Sulphur	...	...	...	4,032	277	22.4	4.1

power of coke is less than that of coal, owing to so large a proportion of hydrogen being driven off in the manufacture of the coke. The heating power of marsh gas, or light carburetted hydrogen, may be said to present an unfair comparison with coal, since the heating power of 1 lb. of coal will be considerably greater than the power of the gas produced from it by distillation. This also applies to coke. One pound of coal having a heating power of 14,796, when made into coke, would have a power, supposing the production of coke to be 60 per cent., of only $13{,}197 \times .60 = 7{,}918$.

The presence of oxygen in fuel acts in a twofold manner in reducing the calorific power, by reducing the actual amount of carbon and hydrogen, and by rendering part of that amount ineffective for generating heat.

Hydrogen in fuel is only useful for the development of heat, when the proportion of it contained in any combustible is in excess of $\frac{1}{8}$ of the quantity of oxygen contained in the same combustible.

A NEW ATLANTIC STEAMER.—One of the largest Atlantic steamers ever built has been floated from the shipbuilding yard of Messrs. Laird Brothers, Birkenhead. The vessel has been named the Spain, and is to form one of the National Steamship Company's line between Liverpool and New York. Her length is 437 ft., her breadth of beam 43 ft., she is of 4,900 tons burthen, and has accommodation for 1,200 first-class and 1,400 steerage passengers. The engines of the Spain are stated to be the largest ever constructed on the compound principle, and the vessel is expected to have great speed both under steam and canvas.

THE General Post-office of Great Britain has decided to at once extend telegraphic communication to Stornoway, in the Western Hebrides. The submarine cable to be laid across the Minch will be some 28 nautical miles in length, and submerged in water of the average depth of 50 fathoms.

ON COMPLETING THE LAUNCHING OF SHIPS WHICH HAVE STOPPED ON THEIR LAUNCHING SLIPS.

By WILLIAM BRAHAM ROBINSON, Esq.

From the "Journal of the Society of Arts."

The Cæsar, a 90-gun two-decked wooden ship, having been prepared for launching, was attempted to be launched on the 21st July, 1853, at the Royal dockyard, at Pembroke dock, but after she had slid down the launching ways some 80 ft., and thus immersed her after-part into the water at high tide, she stopped entirely,* and all the subsequent efforts made that day to move her were of no avail. The declivity given to the launching-slip was the usual amount, and the plank and material used in the ways were also of the usual description. The plank on the launching-slip was pitch pine, a material commonly applied to that purpose at Chatham-yard, though it had not been used at Pembroke for some years previous in launching heavy ships.

Between the 21st and 26th July, some small hollow vessels, built for the purpose, and a few casks, etc., were put under the ship's bottom, below high-water mark, with the view of reducing the weight of the ship on the ways, and at the time of high tide efforts were then made, by means of purchases, to pull the ship off, but all these measures were unavailing.

A careful inspection of the work at low water the night after the ship stopped, and on subsequent occasions, convinced me that the real cause of the failure on the 21st July was the want of a sufficient and proper lubricant between the sole of the ways and the launching-slip, and the sliding surfaces being made too smooth by planing them. Acting on this opinion, and observing that the ship's stern was sufficiently immersed in the water, when the tide was up, to admit of proper vessels being placed so as to lift the ship abaft, I advocated persistently before the then master-shipwright the necessity of adopting the unique plan of building camels for breaking the too close contact that appeared to be established between the sliding-ways and the launching-slip, by lifting the stern of the ship so as to take its weight off the launching-slip. On Tuesday evening, the 25th July, it was determined to build 3 large camels for this purpose. I thereupon caused to be laid off in the mould-loft, in a few hours, a camel to fit each buttock, 72 ft. long, to be planked with 4-in. fir plank, and one for the stern 20 ft. sq. in section, and 48 ft. long to be built of 5-in. fir plank, the collective lifting power, when properly in place, being estimated equal to 1,100 tons. The artificers were set to work from 3 A.M. to 8 P.M. cutting out plank, etc., for these camels, no suitable material being in the yard, and in the incredibly short period of 9 days these large vessels were built and launched, and on the following day, the 5th August, they were got partly into place, under the very great difficulty of having to secure the after one with nothing firmer to rest upon than soft mud. On two subsequent tides, the camels being only imperfectly shored down, and therefore only partially in action, the ship was moved, when a pulling power was applied, 9 ft. and 45 ft. successively; and at last, on the evening tide of the 17th day after the ship had stopped on the slip, the camels having been properly kept down in their places by bearers put out at the quarter-ports on the lower deck, and shored to the main deck upper sills to keep in place the quarter camels, a similar plan having also been adopted to keep down the stern camel, without any pulling power being applied, the ship, about one and three-quarter hours before high-water, abandoned her unworthy connection with the land, and glided gracefully into the haven, amidst the rejoicings of all the people in Pembroke dock. An examination of the launching-slip after the ship had left it, proved that the opinion I had formed had been founded on no hypothetical reasoning, since the absence of grease was apparent enough, and the too great smoothness of the sliding surfaces was equally evident. The camels, it may be added, which have been briefly described, were provided with valves for reducing their lifting power, but it was not found necessary to use them.

* I was not the responsible officer engaged on the launch.

During the 17 days and nights the ship remained on her slip, it was pleasing to observe the interest every man in the yard appeared to feel in the preparations making to get her off; and they worked most willingly day and night, the water drinkers coming out of the trial fresher certainly than many others.

On the 9th August the ship was docked, the stern camel having been kept in place, and 70 tons of ballast having been put on board forward to trim the ship. The sheer of the ship, which had broken when the ship was on the launching-slip about 1 6″, returned in great part to its normal form on docking the ship, and it was held there by the introduction of "double fastenings" in the wales, and by an admirable method of coaking and "keying up" the iron diagonal riders proposed by the then master-shipwright of Devonport yard.

With the experience of the case of the Cæsar stamped on my memory, I surveyed the condition of the Northumberland when she stopped on her launching-slip on the 17th March, 1866, as the Cæsar had done, and I at once observed that her position was just such as would require her to be dealt with in the same way as the Cæsar had been—with this difference, that in the case of the former ship, a very rigid iron hull, which would keep the ways straight and to their form, had to be dealt with, instead of, as in the case of the Cæsar, a flexible body, which would bend, if not well supported, to a large extent before breaking.

On the afternoon of the day on which the Northumberland stopped on her launching-slip (the 17th March, 1866), after I had carefully examined into all the circumstances connected with the position the ship was in, I inquired for the office, and obtained after some trouble a quarter of a sheet of foolscap paper, upon which I briefly described the experience I had acquired in the case of the Cæsar, and proposed lifting the ship abaft by means of camels built for the purpose, or suitable small ships which might be found lying in the river; and this definite proposal I put into the hands of Mr. Lungley, the then manager of the company, when that gentleman was standing alongside the ship.

On a subsequent day I mentioned the subject of the memorandums referred to, to the chairman of the company, but notwithstanding this, nearly the first action taken was to lay a second launching-slip alongside the original one, at a less declivity than the original slip had been laid at. This was done I believe with the view of sliding the ship down far enough for her weight to come upon the slip with the lesser declivity. Together with this certainly very novel arrangement, some means for lifting the ship abaft by mooring lighters, etc., was provided; and on the 2d of April, all being ready, an attempt was made to complete the launch of the ship; but it failed, as I had predicted it would when speaking to the gallant chairman of the company at the head of the ship, just before the event.

Immediately after this failure my proposed plan of lifting the after-part of the ship was adopted, and measures were taken to build the requisite camels in the two neighboring Royal dockyards, Woolwich and Deptford, where the usual willing exertions were exhibited by officers and men; and the four camels—two for each quarter—were built in a very few days; and they were secured in place by the 17th April (just one month from the first attempt to launch the ship being made), and on the rising of the tide they lifted the ship abaft off the launching-slip, when she glided into the river without the help of the large pulling power which had been provided.

The camels which have been referred to were admirably detailed by the officers who built and prepared them, and the valves were most successfully managed on the day of the final launch, so as to prevent the camels from lifting the ship above the ribands on the launching-slip.

The day after the ship left her launching-slip, I, at low water, inspected the slip, the plank of which was oak, not fir, as in the case of the Cæsar, and saw enough to convince me that my first impression had been a right one, namely, that the ship had stopped in the first instance mainly for the want of a proper and sufficient unguent on the ways and slip.

The forces in action when a ship's stern is lifted under similar circumstances to those which obtained when camels were used to lift the after-parts of the Cæsar and Northumberland may be illustrated

as follows, by which it will be seen that it could scarcely be necessary to provide a large pulling power in addition to the lifting power of camels :—

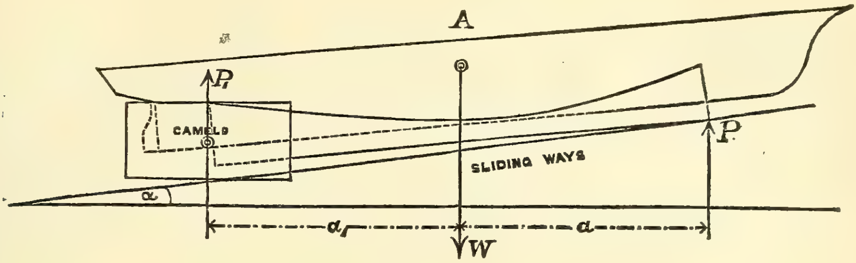


Fig. A, represents a ship in the position I have been describing, and it will be seen that the forces acting upon her are as follows :—

1st. Weight, W, acting downward through the centre of gravity of the ship.

2d. The upward thrust, P_1, of the camels, which is equal to their buoyancy, and acts through the common centre of gravity of their displaced volume.

3d. The re-action, P, at the fore end of the slipway.

The force which acts to push the vessel down the slipway, we will call F, and this will be equal in amount to—

$$\text{P sine L} - \mu \text{ P}_1 \cos \text{L}$$
$$= \text{P (sine L} - \mu \cos \text{L)}.$$

When μ is the coefficient of friction, and depends upon the kind of unguent used, and L is the angle of inclination of the sliding plank.

By reference to the figure it will be seen that—

$$\text{P} = \text{W} \frac{a}{a + a_1}$$

and as a will under most circumstances be nearly equal to a_1, we may take—

$$\text{P} = \frac{\text{W}}{2}$$

and we shall then have—

$$\text{F} = \frac{\text{W}}{2} (\text{sine L} - \mu \cos \text{L}).$$

If the stern of the ship were not lifted, but her whole weight rested on the slipway, the force acting to push her down the slip would be—

$$\text{W (sin L} - \mu \cos \text{L)}.$$

or double what it is in the present case.

The advantages obtained by the use of camels are due to the fact that they take all the weight of the ship off the bilge-ways, except at the extreme fore-end, so that the after-part is lifted clear of any obstruction that may exist ; or, where the grease used is bad or insufficient in quantity, the adhesion of the surfaces in contact is overcome, and they are left free to slide upon each other.

To the foregoing it may be added that due consideration should at all times be given in preparing the "launch" of a ship to the relative weight of the ship and area of the soles of the ways, declivity of launching-slip, and to the time it is intended the ship shall rest in her cradle before the launch takes place, and then finally on the kind and quantity of grease to be used between the sliding surfaces. All these points affect the *stiction* to be overcome in launching the ship.

Origin of Graphite.—Prof. Wagner ascribes the deposits of graphite, plumbago, or black lead, which are found in a great variety of rocks of different geological periods, to the decomposition of cyanogen, which is a combination of carbon and nitrogen, or of the cyanides. In several chemical processes used in the arts, graphite is formed artificially; and it is not impossible that this expensive mineral, the best specimens of which are now brought from the island of Ceylon, may be produced artificially in such quantities as to be made available in several branches of manufactures where this mineral is indispensable. Chemists, however, have not yet accepted Prof. Wagner's explanation, or any other, as to the natural production of graphite.—*Iron Age.*

London is now in direct telegraphic communication with Hong Kong.

THE MAKING AND REPAIRING OF ROADS.

From "The Building News."

A road should be considered as a structure having two essential parts, a foundation and a wearing surface. The duty of the first is to keep up the second to its work, and may be made in any way that satisfies the one condition of unyielding firmness. It has been sometimes said that a slightly yielding or elastic foundation is better than a rigid one; and if that elasticity could be had at a sufficient depth below the surface it might be so, but practically it is not to be had, and the danger of trying to make the foundation elastic far exceeds the objection of rigidity.

A great deal of unnecessary discussion used to be indulged in as to whether the plan of making the foundation which was adopted by Mr. Telford or that practised by Mr. Macadam was the better. Telford's plan was to pitch the road-bed with rough stones, set closely by hand, with their broadest edges downwards, and their greatest length crosswise of the road, the breadth of the upper edge of any stone not exceeding 4 in. All the irregularities of the upper part of the pavement were broken off by the hammer, and the chips packed by hand and wedged into the interstices. The depth of the stones when finished off was 7 in. in the middle part of the road, 5 in. at a distance of 9 ft. on each side of the centre, 4 in. at 12 ft., and 3 in. at 15 ft. The surface thus formed a curve, having a rise of 4 in. in the centre. This is clearly a good foundation, but it is somewhat against it that the bed is flat, and that if water should percolate through the top coating and through the pavement it would, on some kinds of ground, as upon clay, weaken its bearing power; but if the ground is porous, as sand or gravel, or rocky, as it was on most parts of the great Holyhead road made by Mr. Telford, this objection to a flat bed does not arise. Whenever the bed, however, consists of clay or other impervious ground, the bed should be sloped downwards from the centre to the sides to about the same extent as Mr. Telford allowed—viz., 4 in. in a width of 15 ft., so that water may drain away. Two straight slopes for this purpose are better than a curve. Macadam, on the other hand, considered this pavement foundation to be unnecessary, and insisted that the native soil, properly formed and drained, must be considered to be the foundation, and carry the weight of the traffic; and that whatever stone may be laid on is only to preserve this foundation from injury, and its thickness should be regulated only by the quantity of material necessary to form such a protection, and not at all by any consideration as to its own independent power of bearing weight; and that it is an erroneous idea that the evils of an undrained, wet, clayey soil can be remedied by a large quantity of materials.

But what makes the discussion upon the two methods of little use, is the fact that Macadam's own practice approaches that of Telford, for on laying on the broken stone he was careful to lay first a layer 3 in. thick, and have that pretty well consolidated by traffic before any more was put on; and this and the succeeding layer may be taken to stand in the place of the pavement of Telford. The native surface having been formed, Macadam's system was to lay first a layer of 3 in. of clean broken stone on a dry day, and after the traffic had almost, but not quite, consolidated it, the ruts being kept raked in as soon as they are formed, a second layer of 3 in. was laid down in a wet time, moisture facilitating the union of the two.

Then the third layer forms the top coat, and carries the traffic. Macadam insisted strongly on the necessity of the stones being clean and angular, whereby the angles interlock with each other and form a solid structure; whereas, if other material be admitted under the pretence of binding, it prevents this close union, absorbs water, and in frost disrupts the mass. Macadam's method of laying the foundation—that is, the first two layers of broken stone—has the disadvantage that in wet clayey ground the traffic forces the stones into the ground, and it rises through the interstices, although Macadam maintained that draining would prevent this. Draining, however, cannot altogether prevent it, and it is only to be prevented by selecting a dry time for laying down the first layer of stone. The first layer being accomplished, the second becomes easy. Telford's pavement is easy under any

circumstances and in any weather, but is more expensive. It has the advantage, however, of distributing the weight on the surface over a large area of foundation, for if we take a wheel touching 2 sq. in. of the surface, the pressure is carried down to the foundation stones, which rests on a broad surface of, say, 10 in. by 5 in., or 50 sq. in., so that the bearing surface is multiplied 25 times. To prevent the displacement of the foundation stones, the carts bringing the stone were not allowed to pass over them.

The foundation, then, having been laid, whether of one or the other kind, or in any other way, so that it be unyielding (in the manufacturing districts engine ashes are largely used, and make a very good foundation, laid on 7 in. deep in two layers, the traffic being allowed to pass over them before the top coat is put on), the wearing coat has then to be put on, and now the quality of the stone comes into question. The most durable stone is that which is toughest. Mere hardness is no test of quality for the purpose of road making. Flint is hard enough, but it is almost the worst material for a road, because it has no toughness.

In his "Discourse on the Study of Natural Philosophy," Sir John Herschel says:—"Hardness is that disposition of a solid which renders it difficult to displace its parts among themselves; thus steel is harder than iron. The toughness of a solid, or that quality by which it will endure heavy blows without breaking, is again distinct from hardness, though often confounded with it. It consists in a certain yielding of parts, with a powerful general cohesion, and is compatible with various degrees of elasticity."

The most useful stone is that which is most difficult to break up. Such is the blue granite of Guernsey; a trap rock found at Clee Hill, in Shropshire (the Clee Hill Dhu stone); a stone got near Macclesfield, in Cheshire; the whinstone of the north of England; the Penmanmaur stone from Wales; beach pebbles and boulders; a stone brought in the bottoms of ships as ballast from Bombay; another from Port Philip; and other such kinds of stone. Stone of secondary quality is the carboniferous or mountain limestone, and the harder sandstones. Broken flints form a third quality, and the lowest is flint gravel. This last is unfit for anything but by-roads. It is very extensively used in the south of England for all kinds of roads, but it is not economical to use it where there is considerable traffic. The comparison of the strength of different kinds of stone by the steady weight that pieces will bear before crushing is not admissible in the case of road-stone, for the weight it has to bear is not a steady one, but one of impact. Most of the roads round London are made with flint gravel, and in the coaching days there was a select committee of the House of Commons upon highways, and before that committee evidence was given that for the first few stages out of London it required ten horses to do the same work that eight did beyond them, and that the horses out of London, although better animals to begin with, were worn out in four years, while on other roads they would last six years. It may be laid down as an axiom that it is more economical to bring good materials from a distance than to use inferior ones obtained close at hand. Thus, in London, for the heaviest traffic it is more economical to use Clee Hill Dhu stone at 16s. 3d. per ton, Enderby stone at 15s. 6d., and Guernsey granite at 15s. 6d., than any other stone, although the prices are less; and at Manchester they use the Penmanmaur stone at 12s. per cubic yard rather than other stone which might be had much nearer. The thickness of this top coat is not of much consequence; it is only required to protect the foundation from the action of the traffic; and may be any thickness that is convenient; and the most economical thickness will be determined by considerations of labor—how much it costs to lay down a coat of 2 in., one of 3 in., one of 4 in., and if 6 in. be put on it must be put on in two layers of 3 in. each, and then how much will that cost? And each of these costs must be compared with the standard of wear, which will be the same whatever thickness the coat of stone may be; and in this, as in many other things, the middle course will more often be right than either extreme, and it will generally be found that from 3 to 4 in. is the best thickness. It is true that on such a foundation as Telford's more than this is required above the pavement, or the road would be too rigid; and accordingly Telford directed that 4 in. of broken stone should intervene between the pavement and the top coat of stone.

"The middle 18 ft. of pavement is to be coated with hard stones to the depth of 6 in.; 4 in. out of these 6 in. are to be first put on and worked in by carriages and horses, care being taken to rake in the ruts until the surface becomes firm and consolidated, after which the remaining 2 in. are to be put on." The next thing to be considered is the size to which the stone of the top coat shall be broken. Both Telford and Macadam said, to such a size that its longest dimensions should be not more than $2\frac{1}{2}$ in., which would be, for average materials, cubes of about $1\frac{1}{2}$ in., and Macadam further directed that no stone should be more than 6 oz. in weight. But neither dimension nor weight can be accepted as logically defining the proper size, because that depends upon the nature of the material. To reduce flint or sandstone to the dimensions proper for traprock and granite, would be to insure their immediate grinding up and removal from the road. But there is no doubt that for the better kinds of stone the size can hardly be too small, so long as they are broken to a uniform size, and here the superiority of hand-broken stone over that broken by machine is very evident. Hand-broken stone is more uniform in size, and approaches more nearly to the best form—the cube—than can be had with any machine, for while the machine breaks up some of the stone into too small fragments, it cracks many of the pieces of the right size, and thus when the traffic comes over them they split, and they are split also by the action of frost. We believe the French engineers disregard the cleanliness and uniform size insisted upon by Macadam, and allow even dust to be mixed with the clean angular stone, but we are convinced that this is a mistake. The object of having the stones clean and free from extraneous matter, is that they shall interlock, and the angles adjust themselves so as to come home, stone to stone, and so form a solid body; but when dust or other substance is allowed to come into the cavities they cannot do so, and are thereby rendered less stable. It is probable that the success of the French engineers in making roads is due to the attention they pay to rolling the surface; but even by that means they cannot force the stones into contact when dust intervenes. Breaking stone would seem to be a simple thing enough, and one that any able bodied-man may do as well as another, but it is not so. In the first place, it requires a particular kind of hammer. The head must be of solid steel. The shape of the face of it must vary with the kind of stone to be broken. The handle must be pliable, and not a stiff piece of wood—it must therefore be a green stick—and hazel or ash plant is used. Then a stone-breaker must know where to hit the lump he is to break, and where he shall hit it depends on the nature of the stone. A great deal of strength is wasted by men unaccustomed to stone-breaking, who take up the work for the first time, and work with tools of the wrong kind.

The shape of the surface of a road is important. There are three forms of surface; one, the most common one, a curved surface, having a rise from the water channel to the crown of 4 in. or 6 in.; the second form is the straight slope on either side of the centre; and the third the hanging road, where the slope is all to one side, the road having only one water channel. In the latter case it is generally dictated by local circumstances, but the other cases are general. The higher the crown is made above the water channels for the sake of getting the water quickly off the road, the more is the traffic restricted to the centre of the road, for nobody will drive on sidelong ground if he can get a level footing. There is not much difference between the two forms, for if the road be made at first with straight slopes it will soon become worn down at the apex into something like a curved form. But there is a good deal to be said against the practice of raising the centre of the road too much in either way, for the object ought to be to get the traffic spread equally over the width of the road, and thus we come to the conclusion that as little rise as possible should be given to the crown; and 3 in. in 10 ft., or 1 in 40, is sufficient to allow the water to run off, and if it takes a longer time to run off such a road than it does on a more rounded one, that is of less consequence than unequal wear.

The road having been formed, it has to be maintained as nearly as possible in its original form, There is no stone that is of exactly a quality throughout, and the reason why a road wears into holes is that the softer parts here and there are

worn away before the rest, leaving the hardest portions of the stone standing up in ridges or knobs, and when this attains to a sufficiently objectionable degree the holes are to be filled up with new stone broken very small, and no more stone used than is sufficient to bring the surface up to the level of the adjoining unworn portions of the road.

The common error is to put too much stone on a place that wants some mending, and many roads have been raised considerably above their original level. The object should be to keep up the thickness of the metalling as nearly as possible to that it originally had. This cannot be done absolutely, but it can be approximated to ; for instance, if the original thickness of the top coat be 4 in., 1 in. of the best part of the material, as well as that used for patching, will be worn away in, say, twelve months, leaving the thickness no where more than 3 in. It will be proper then to repair the road with a fresh coat of stone, raising the thickness to, say, 5 in., which would then allow two years' wear before another coat of stone would be required.

Whenever a new coat may be necessary, the surface of the road is to be picked up to a depth of 2 in., the surface readjusted in form, the material sifted and relaid, with the addition of as much new stone as may be required to make up the 2 in. The time of year most suitable for repairing roads is the spring ; the succeeding summer then hardens the road and leaves it in a good condition to resist the traffic during the wet winter months.

Of the new asphalt roadway, the English experience is not yet sufficient to enable us to judge of its durability; but so far as it has gone the wear appears to be absolutely nothing in Threadneedle street and Cheapside, and the smoothness and noiselessness are much in its favor ; but although it may ultimately be generally used, stone paving will probably continue in use for many years for the heaviest traffic, although the objections to it, even to the best kinds of stone, are numerous, and some kinds of stone are simply abominable from their slipperiness ; and the noise that a stone-paved road produces is such that where the residents have sufficient influence over the parish or other local authorities, they prevent it being laid down, and in other instances, where the appeals against it have been unsuccessful, residents have vacated their houses, and the authorities have lost the rates upon the property. The only thing that can be said for stone paving is that it costs less in maintenance than a macadamized road does, where the traffic is excessively heavy ; but when we come to get broken stone properly rolled and set before the traffic is turned on to it, there will be some hope of the more extensive use of that kind of road.

THE MINERAL WEALTH LOST TO FRANCE.

From "The Mining Journal."

Commissaries have been charged by Germany with the task of definitively adjusting at Brussels the conditions of the treaty of peace between France and Germany, and the German officials comprise a gentleman associated with mines. It is inferred from this circumstance that Germany is aiming at an industrial preponderance in Europe as well as at a consolidation of its military power. This policy will, probably, be attended with important consequences, not only for France and Germany, but also indirectly for Belgium and England. In consequence of the mineral wealth of the departments in the east of France, the French iron trade gradually acquired considerably increased importance during the 15 years ending with 1870 inclusive, although since last July it has, of course, been greatly depressed by the course of public events. In 1850 the total production of pig in the French furnaces amounted to 500,000 tons, of which about half was made with charcoal. The production had risen, however, in 1867, to 1,222,363 tons, and in 1868 to 1,274,333 tons, less than one-fifth being made with charcoal. Exact returns for 1869 and 1870 have not yet been made up by the French Government, but the production for 1869 has been estimated by the French Committee of Forgemasters at 1,380,000 tons, so that the production of pig in France would seem to have nearly

doubled within the last 20 years. In 1867, out of the whole total of 1,222,363 tons of pig made, the department of the Moselle produced 281,045 tons, or about one-fourth of the whole, and it is probable—although precise statistics on the subject make default—that considerable further progress was made in the Moselle during 1868 and 1869, as of all the French metallurgical groups it has generally displayed the greatest activity.

It is upon this fine district that Germany has this year laid its hands, in consequence of the collapse of the military power of France before the terrible legions of Prince Bismarck and Count Von Moltke. Through the new delimitation of her frontiers the Longwy basin has alone remained to France; and taking the statistics of 1867 as our guide, it would seem that the delimitation will be attended with the following results:

Work remaining in France.

Establishment.	Furnaces.	Production. Tons.
Gorcy	3	5,457
Mont St. Martin	2	19,425
Longwy Bas	2	8,542
Le Prieuré	2	15,447
Moulaine	2	10,905
Senelle	1	4,200
Rehon	2	12,490
Total	12	76,466

The following will be transferred to Germany:—

Works in Alsace and Loraine.

Establishment.	Furnaces.	Production. Tons.
Styring-Wendel	3	45,943
Hayange	5	50,563
Moyeuvre	3	37,044
St. Paul. St. Benoit Ars	4	27,540
Ars-sur-Moselle	1	9,070
Ottange	3	13,928
St. Claire	1	2,389
Mauterhausen	1	2,445
Novéant	1	12,324
Villerupt	2	2,233
Audun-le-Tiche	1	1,100
Total	25	204,579

Three-fourths of the production of the old department of the Moselle will thus be diverted into the Zollverein, and the works ceded from the power of their capital, the force of their tools, and the extreme richness of the mineral bearings conceded to them, represent more than the proportionate share which they sustained in the total production.

It would appear that the Prussian plenipotentiaries have traced out the new frontier, not on any topographical plan, but very probably on a geological map prepared at Berlin. It is noticeable, for instance, that the new limits between France and Germany absorb, to the profit of the Germanic Confederation, all the rich bearings of oolitic ironstone in the Moselle and the Meurthe, the Longwy group excepted. Thus the concessions remaining in France comprise an area of 5,336 acres, producing, according to the last available return, 140,281 tons per annum, while the concessions in Alsace and Lorraine tranferred to Germany comprise an area of 18,062 acres, with a production of 500,660 tons per annum. The "Moniteur des Interets Materiels" considers that the relative production of pig in various European countries will be rather profoundly modified by these changes, and compares as follows the production of pig in 1866 with the estimated production of 1872:

Country.	Production, 1866. Tons.	Production, 1872. Tons.
Great Britain	4,592,000	5,100,000
France	1,253,000	1,062,000
Zollverein	1,079,000	1,907,000
Belgium	421,000	526,000
Austria	292,000	365,000
Sweden	236,000	293,000
Russia	350,000	420,000
Other countries	90,000	100,000
Total	8,313,000	9,773,000

The proportion sustained by Great Britain in the total production will, according to this estimate—which, after all, is rather curious than reliable—thus fall from 55 per cent. in 1866 to 52 per cent. in 1872. That of France will also fall from 15 to 11 per cent., but that of the Zollverein will advance from 13 to 19 per cent.

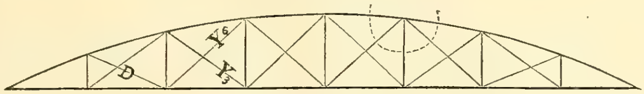
Titanic Ore.—At the last meeting of the metal and coal trades at Swansea, a sample of titanic ore was exhibited containing a very large percentage of titanium. The price of the ore was 25s. per ton exship in the Bristol Channel. An analysis of this ore yielded the annexed results: Iron, 40.88 per cent.; oxygen, 20.57 per cent.; titanic acid, 31.72 per cent.; silica, 3.17 per cent.; lime, 0.97 per cent.; magnesia, 1.00 per cent., etc.

The State with the greatest railroad mileage is Illinois, which has 7,186 miles.

CALCULATIONS OF STRAINS IN TRUSSES.—NO. III.

A reference to the calculations in the last article shows that the method applies to the diagonal and vertical members of a truss, because these take the greatest strain when the girder is partially loaded. To determine the law of dependence of strains upon the distribution of the load, it is only necessary to consider the general equations of moments, and to represent by diagram the girder in the condition corresponding to the omission of positive or negative members. It is thus

Fig. 1.



seen that any diagonal as Y_3 in the third bay receives a maximum tension if all apices at the right are loaded; and a maximum compression if all points at the left are loaded. If, in the same bay, instead of a diagonal sloping to the left, one sloping to the right be substituted, the reverse would be the case. For, if the girder is viewed from behind, the diagonal Y_6 appears in a corresponding position, and the equations of moments would also correspond.

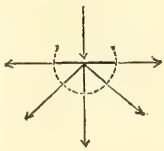
If both diagonals appear, and are constructed as ties or tension-members, not capable of compression, each is brought into action only by a distribution of load that causes tension, while the other is in the condition of a cord just stretched without strain. In this case only the maximum valves of Y enter; *e. g.*, in the third bay, for the diagonal Y_3 (max.) and for the diagonal Y_6 (max.). In a similar manner the strains of all diagonals can be found.

For vertical members of such a girder only the minima of the valves for V are taken into account, because tension cannot occur in them, if each of the diagonals meeting at a vertical is incapable of receiving compression.

A glance at Fig. 2 shows that this is impossible, otherwise the vertical force V would be taken up by no opposing force. That these minima apply to a girder with intersecting or crossing diagonals appears from the consideration that for a load on one side, only one of the two systems of diagonals is strained, so that the other need not be taken into account.

Hence with the results obtained, as in the last article, the magnitudes of the greatest tensions may be written on the corresponding diagonals.

Fig. 2.



If the diagonal members are constructed so as to receive compressions, as in the case of wooden trusses, an entirely similar process is adequate to obtain the desired results; but only the minima for diagonals and the maxima for verticals remain the same. As to the minima, it is plain that if the diagonals cannot convey tension, the direct load is the only one that can cause compression in the verticals. This varies (in the case of the last article modified for this occasion) between 1,000 and 1,000 + 5,000; hence

$$V\ (\text{min.}) = -6{,}000\ \text{k}.$$

The strains from left to right are as follows (for loads as in last article, for truss with intersecting or isosceles diagonals):

	Bay 1.	2.	3.	4.	5.
Upper chord	— 48,000	— 48,000	— 48,000	— 48,000	— 48,000
Lower chord	+ 52,500	+ 50,300	+ 48,900	+ 48,100	+ 48,000
Verticals	— 6,000	— 6,000	— 6,000	— 6,000	— 6,000
Diagonals sloping to right	..	— 6,250	— 6,850	— 7,080	— 6,850
Diagonals sloping to left	..	— 5,470	— 6,250	— 6,850	— 7,080

In case of diagonals sloping only from the centre towards the abutments, the tension depends exclusively upon that of the chord segments intersecting at the foot of each. These are always subject to tension and therefore can only cause compression in the verticals. This is a maximum for a full load.

If the diagonals slope only from the abutment towards the centre, the direct load alone causes a strain in the vertical members.

IRON ABUTMENTS.

From "The Engineer."

Although there are abundance of instances in which iron, both cast and wrought, is the material used for the piers or intermediate supports of bridges, the examples are comparatively rare in which it is also employed for the terminal supports or abutments. It might appear, at first sight, that if the nature of the foundations rendered it advisable to adopt iron in the piers, the same conditions would dictate the use of iron in the abutments. But there are many reasons which demonstrate that this view is not necessarily correct or conclusive. In the first place, the character of the substratum in a tolerably wide river, often differs at different parts of the transverse section, and it is seldom that both abutments are founded at exactly the same level. There is a notable difference in the nature of the ground on the Surrey and Middlesex shores of the Thames, for example, and a dam that would fully answer its purpose on the one might not always be sufficiently strong on the other. This fact was well shown during the construction of that portion of the Northern Embankment near Blackfriars Bridge. Our readers will probably remember that a serious "blow" occurred in the dam, and yet this dam was almost identically similar in design to that which did its duty so well during the building of the river wall from Westminster to Vauxhall on the Surrey side of the Thames. On geological grounds, therefore, alone, brickwork or masonry might be well adapted for the abutments of a bridge, and yet be superseded by iron, with advantage, in the more central and deeper parts of the stream. It is not, however, until we come to regard the different duties a pier and an abutment have to perform, which necessitate a diversity in constructive detail, that the real reason of the general unsuitability of iron for abutments becomes manifest. The sole duty that a pier has to perform, so far as relates to the actual bridge itself, is to bear the direct vertical pressure of so much of the superstructure as falls to its share. There are no doubt in many instances other forces in operation which try its stability and strength, such as the velocity of a marine or river current, the impact of ice, or the concussions of floating bodies, but these are beside our subject. It is otherwise with an abutment. In addition to bearing its own share of the direct weight of the superstructure, it has to act as a retaining wall. It will be understood that at present we are speaking of those forms of bridges which exert no thrust against either the piers or abutments. As every bridge must have an approach to it, which is most frequently of earth, it is the necessity of making the abutment support this, that gives masonry or brickwork a decided superiority over both cast and wrought iron. Neglecting the value of the limiting angle of friction of the material, the horizontal pressure against the abutment will be directly proportional to the sheer mass or weight to be resisted, and common sense would instruct us that in all similar cases weight is best resisted by weight and solidity.

So far we have only taken into consideration that portion of the end supports which may be termed the abutments proper, but this is seldom sufficient of itself to retain the whole cross section of the approach. The retaining wall, regarded as a whole, comprises not merely the central vertical part which carries the superstructure, but the side portions as well, which have no vertical load to support, and are known as the wings of the bridges. These may be either "straight back" that is, built in a line parallel to the direction of the bridge, or "splayed,"

that is, receding from the face of the abutment at any given angle. In the former instance the top of the wing wall is horizontal, and in the latter, which is the form under present notice, the height diminishes from a maximum at its junction with the abutment to a minimum at the newel, the slope being parallel to that of the embanked approach. It is in the wings that the chief difficulty of employing iron with economy would be met. In the abutment proper a certain degree of strength is required to carry the vertical load, and this amount can be simultaneously utilized as a contribution to the total necessary for the retaining wall. On the other hand, the wings act simply as retaining walls, having no vertical weight to bear, and the question becomes reduced to one involving the relative economy of iron and masonry or brickwork. Without desiring for a moment to place a limit to the skill and ingenuity of engineers, yet we hold that for certain purposes certain materials are more suitable than others, and that the substitution of the wrong for the right is only effected at a commensurate sacrifice on the score of economy. Except in examples such as armor plating, targets, and engineering works of a warlike character, the substitution of iron for the older materials used in construction, will generally be found to be nearly equivalent to the substitution of the hollow for the solid form. Take the earliest, the cast-iron flanged girder. It is nothing else in form than a beam with the material cut away about the centre. The same statement holds good for wrought-iron girders, and the hollow column is only the stone pillar with its core extracted. It is not difficult to understand that a given amount of metal which would be able to support a given vertical weight would be quite inadequate to resist the same weight acting in a horizontal direction, or at an angle with the horizon. In the one case, supposing that there was no bending moment induced, the iron would only yield to a weight equal to its crushing pressure; in the other the resistance it would give would depend upon the direction of the strain it was subjected to. Iron wing walls must evidently consist of plates which, *per se*, have little or no stability, and this feature can only be imparted to them by the addition of stays and bracing. Some years ago we expressed our views on this very subject, and shall not recapitulate them, though we may observe that we have since seen no reason to alter our opinions.

Our attention has been again drawn to this question by a paper lately read before the Institution of Civil Engineers, "On the New Ross Bridge." In this case the abutments and wing walls consisted of cast-iron cylinders with cast-iron plates fitting in between them, and a strong backing of concrete, which is tantamount to so much solid masonry. The design of the cylinders and plates is precisely analogous to that constituting the foundations of the piers of Westminster Bridge, if we substitute piles for cylinders, and is nothing else than a cast-iron frame and panelling. The relative economy of this method of construction depends wholly upon the difficulties that may result from the presence of water. To build a retaining wall on dry land of cast-iron framing and panelling, to support a 25-ft. embankment, would be simply a great and unjustifiable waste of money; but to employ the same design in 25 ft. depth of water is another matter altogether. As a rule, it is certainly more expeditious to sink cylinders under water, and drive down panel plates between them, than to construct a temporary dam and build a solid wall of masonry and brickwork behind it. But it is not always so. If it can be satisfactorily established before the commencement of the work, that, from the nature of the substratum, there will be no trouble with the water, it is more than probable that the temporary dam and the solid wall would come quite as cheap as the cylinders and panelling. It is true that the latter plan dispenses with the temporary dam, but the sinking of the cylinders is not all plain sailing. It must also be borne in mind that, wherever cylinders are easily got down, it is equally easy to drive timber piles and construct a dam. Omitting the contingent difficulties in dealing with water, the actual cost of the two systems will differ to some extent, and the balance will be in favor of the solid wall. In the first place, the diameter of the cylinders will exceed the mean thickness of the solid wall, and the cement, concrete, or brickwork, with which they are filled, would materially contribute towards its construction. Calcula-

ting the cost of cast-iron panelling per sq. ft., and that of brickwork upon an average thickness in each case, the latter will have a slight balance in its favor. An instance recently came under our observation in which there is no doubt the employment of cast-iron cylinders and plates would have been advantageous. The case was a very exceptional one. The bridge was absolutely *a fleur d'eau*, the span being 50 ft. and the limit of headway from the surface of the water to the top of the metalling being only 2 ft. 6 in. The approaches were, therefore, virtually nothing, and consequently no wing walls were required. It was merely the question of the relative expense of sinking the cylinders and constructing the temporary dam. Apart from these considerations, there are one or two others which must not be disregarded when reviewing the whole subject. It is with pleasure that we are enabled to state that there has at last sprung up some desire among eng neers to render their works more prepossessing in appearance than formerly. We will not go so far as to assert that they aspire to real æsthetical excellence on this point, but even this end may be ultimately attained. Sufficient progress has at any rate been made to warrant the statement that some regard must be had to appearance in all future designs. It is difficult to perceive how cast-iron framing and panelling would compete with masonry in this particular, without the incurring of expense that would be practically putting a veto upon the design. Genuine ornamental cast-iron work is of a very costly character. We have known as much as £140 per ton paid for it.

As a last consideration, that of durability must not be passed over. There are so many different opinions respecting the behavior of cast and wrought iron when exposed for some time to the action of either salt or fresh water, that no positive conclusion can be arrived at on the matter. Cast iron that has been exposed to sea water has been found so soft that it could be cut with a knife ; and, on the other hand, it has stood comparatively uninjured for years, in almost exactly similar situations. If we are not in a position to state the probable period that iron will remain in a sound condition under the circumstances alluded to, we can at least safely predict that good masonry or brickwork will in any case last as long as iron. The existence of the ancient Roman sewers and walls is a proof that there is, or perhaps, rather, was, a description of brickwork which may be pronounced practically indestructible. At the present day we may not quite come up to this standard of work, but it is possible we may go very near to it. It is alleged in favor of ironwork, that when it does rust the very rust itself acts as a protection against the further action of the cause that produced it. This may to some extent be true, but it must not be forgotten that rust never quite protected iron yet, and the argument is of small value. The durability of cast iron in the position under notice will be lessened if there is a tidal action at work, as the effect of alternate exposure to water and air is not confined solely to timber, but extends to metallic substances as well.

The Sherman Process, of which so much has been said and written in England during the past few months, appears to be losing favor. At the last meeting of the Iron and Steel Institute in London, such prominent iron-masters as Messrs. Menelaus of Dowlais, Hopkins of Cleveland, and Mr. I. L. Bell, stated that the results following his process were quite inappreciable. Mr. Siemens said that when he first heard of the process which claimed with an ounce of "physic" to drive out all the sulphur and phosphorus in a ton of iron, he knew such a result was impossible, and the experiments which had been made proved the correctness of his opinion.

Prof. G. Bischof, of Bonn, Prussia, is now in England with his apparatus for testing metals, which will have a place in the International Exhibition. The method of testing the quality of malleable metals and alloys consists in bending strips thereof alternately in contrary directions until they fracture, the number of times they are bent being duly recorded ; whereby a trustworthy and accurate indication is obtained of the quality of the metal relative to standard measurements previously ascertained.

ON THE IMPROVEMENT OF THE CHANNEL SERVICE BETWEEN FOLKESTONE AND BOULOGNE, AND THE VESSELS PROPOSED TO BE EMPLOYED.

By MICHAEL SCOTT, Esq, M. Inst. C. E.

From the "Journal of the Society of Arts."

On the present occasion the author proposes to confine his observations to the Folkestone and Boulogne route. It may reasonably be inferred that one effect of the recent disastrous war will be to postpone, perhaps for many years, the expenditure of large sums on local improvements in France. If so, it will be vain to expect that deep-water harbors should be constructed on the French coast, for the purpose of improving the communication with England. And it may be assumed that the formation of a deep-water harbor on the French coast would necessarily involve the construction of very costly fortifications for its defence; and, having regard to the present exigencies of the national exchequer, and to the financial condition which is likely to obtain for many a year, it does not seem probable that the French Government would care to undertake such works.

Beyond this, the author holds that, even were the money forthcoming, the period is still distant when the traffic could be expected to yield an adequate return on a large additional outlay.

On the threshold of the inquiry it will be necessary to discuss the necessity or otherwise of such service being at fixed hours, independent of tide or weather. For the mails, fixed hours are no doubt essential, but Folkestone and Boulogne are not the mail ports, and it has been affirmed that a comparatively minor expenditure would render the mail service quite regular between Dover and Calais.

For passengers, it might be said that, being independent of tide, the most convenient hours might be fixed and adhered to, whereas, with a tidal service, passengers have to leave London and Paris at different hours, and sometimes to arrive inconveniently late.

No doubt change of hour is essential; but it is not alone because the service is tidal that passengers have occasionally and necessarily to arrive late, but partly because of the length of time occupied in the journey; and therefore if, as it will hereafter be shown it is, it were practicable to reduce the time from London to Paris from 9½ hours to from 8½ to 8 hours, whilst the time for starting might not be altered, the latest time for arriving, and that only for a few days per month, would be about 10.30 P.M.

There is something also in the fact that, even assuming that an hour might be fixed which might prove most convenient for the majority of travellers, any one time would not necessarily be desirable for all. For example, to leave early in the morning might be most convenient for a business man, but it might not suit a delicate person or an invalid; and it is an advantage of the tidal system, that a choice of several different hours is offered.

As, however, so much has been said in commendation of fixity of service, especially as regards passenger traffic, let it be assumed that it would possess advantages, and let us proceed to consider what practical objections exist to the introduction of such a system. To go no further, it will be sufficient to advert to the want of the depth of water in the existing harbors, which precludes the possibility of a vessel sailing at or near a fixed hour. Hence the advocates of such a service state that, before their views can be carried out, well-sheltered harbors, with deep water, must be provided on both coasts, and thus a fixed service would involve great cost.

What is the value of fixity of service? Is it worth, and would it at present compensate for, an enormous additional expenditure of capital, not to mention augmented annual charges?

The author's proposals may be briefly summarized as follows:—

To provide for a tidal service between Folkestone and Boulogne, and taking care that the vessels, in size and cost of working, did not exceed the paying capacity of the trade, to quote Captain Tyler's recommendation, by "larger* ves-

* See that gentleman's valuable Report to Board of Trade.

sels with less movement in rough weather, more shelter, and better accommodation generally;" and, in order to effect this, to carry out certain improvements in the harbor of Folkestone, leaving the French authorities to do the needful at Boulogne, which will probably only include the works now being executed for increasing the backwater, and the arrangements for the landing and embarkation of passengers at the west side of the harbor. The author has not had an opportunity of minutely examining the harbor of Boulogne, but, judging from general knowledge of the port, his strong impression is that little or nothing more would be necessary.

Before proceeding to describe the vessels recommended as suitable, it is important to draw attention to the fact that storms are the exception, not the rule; and it seems only reasonable, whilst not ignoring the exceptions, that the arrangements made should have regard chiefly to the conditions which constitute the rule.

Captain Tyler says, in his report, that Captain Boxer, R.N., calculates that there are out of the 365 days, 29 days of gales and storms with heavy seas; 102 days of good round sea and breezes; 144 days with moderate weather and sea; and 90 days of calm weather. Adding to the 90 days of calm weather 144 days of moderate weather and sea, we have 234 days, or about two-thirds of the whole year, during which it may be affirmed that on board moderately large vessels no inconvenience would be felt from either rolling or pitching, and during an additional 102 days such vessels would have but little motion. There are thus left 29 days of gales and storms during which it may be assumed there would be considerable motion, even in the largest ship. But it should be observed—

1. That gales and storms occur principally during the winter, when the passengers are few, less than one-third of those travelling in summer; and therefore the number of days of bad weather is not a correct index of the number of persons who suffer from it.

2. Numbers of passengers avoid crossing in storms, and wait until they have blown over.

3. Any kind of vessel which could be employed would have motion in storms, and, if very large, there would be corresponding difficulty in handling them in the harbors, whilst the fares, from the small number of passengers crossing in the winter, would not meet the expense of running vessels of extraordinary dimensions, and, even if they possessed superior steadiness, it would not be required in summer.

Having now come to the vessels which it is proposed to employ, the chief requirements would appear to be—

1. That they should be steady, or have as little movement as possible in rough weather.

2. That they should be so large as to provide sufficient shelter, roomy, airy cabins, ample promenade space on deck, and every convenience for a large number of passengers.

3. That they should have high speed.

4. That they should have exceptional steering powers, and their machinery be extraordinarily handy, so that in the worst weather they might enter and leave the harbors with safety, be easily swung in narrow and confined spaces, and be able to avoid collision with other vessels in thick weather.

5. That, in addition to ordinary holds, the vessels should be constructed to carry on deck the vans loaded with passengers' luggage, and a number of goods-wagons, sufficient, so far as the more valuable kinds of goods are concerned, to accommodate the trade, and so transfer both luggage and merchandise (excluding very light and bulky articles) from one side to the other without breaking bulk.

Having explained his views as to what gives to a ship stability and steadiness at sea, which he does not consider as being synonymous terms, the author says:—

In the case under consideration, what we have to do is to give up sail, and diminish the amount of stability required, and then further to augment the steadiness by every reasonable means.

Much light has in recent years been thrown upon this question, and it is held that, *cæteris paribus,* we have a measure of the relative steadiness of vessels, in the position of the centre of gravity in relation to the metacentre; for it has been found that as these centres approach each other the stiffness decreases, but the steadiness increases, and *vice versa.* From this it follows that the nearer these centres

can be brought the better, if we want a remarkably steady ship ; and this may be effected—first, by diminishing the breadth of the vessel ; second, by increasing the displacement or draught of water ; or third, by raising the weights of or in the vessel.

The effect of the opposite conditions is seen in ordinary steam vessels of light draught and high speed, which involves great weights of engines and boilers low down ; hence such boats are unsteady and roll violently.

Lastly, on this point, as affecting rolling, it has been found advantageous to have the means of winging the weights.

In vessels for the channel service it obviously would not do to restrict their breadth, because this would be to diminish the space required for the comfortable accommodation of the passengers. Nor is it apparent at first sight how vessels with increased displacement and draught of water could make use of the existing harbors, or how their weights could be raised ; but a brief outline description of the proposed steamers will show how steadiness may be secured in the manner indicated without involving what appears to be the corresponding disadvantages.

The author proposes that the vessels should be about 300 ft. in length between perpendiculars, and very little more over all, and about 36 ft. in breadth. The ordinary draught of water to be 8 ft. 6 in. with all weights on board, including passengers and their luggage and a considerable quantity of goods ; and the vessels to be so constructed that, by the admission of water ballast when at sea in bad weather, they would be steadied by having their draught increased to 11 ft.

The vessels to be propelled by two pair of paddle-engines driving one pair of wheels amidships, and the speed to be 17 knots. Having two independent sets of propelling machinery, the vessels would require no masts, sails, or rigging.

It is further proposed that there should be three cabins for first-class passengers, viz., a main saloon, a ladies' saloon, and a cabin where refreshments could be obtained, and that there should be an after-cabin for second-class, and a fore-cabin for third-class passengers.

The first-class ladies' cabin would consist of a lofty saloon, before the machinery ; further aft would be the main saloon, of large dimensions ; and in connection with all the cabins there would be lavatories and other conveniences.

In addition to the unoccupied main deck fore and aft, and over the machinery, and to the wing passages along each side of the saloon cabins, there would be an extended promenade on the upper deck.

It is intended that the vessels should be constructed with double bottoms and double sides—in fact, except at the ends, the construction would be, to a great extent, like a hull within a hull ; and, excepting where the steam machinery intervened, there would be a lower deck, all fore and aft, and water-tight athwartship bulkheads. The result would be great strength combined with lightness, and what is very important, security in the event of collision.

There are other reasons for adopting the construction described, which need not at present be adverted to; suffice it to say that the vessels would be almost unsinkable, a matter of some moment, considering that their course lies directly across the track of ships passing up and down the Channel. Spaces would be provided into which water ballast could be introduced, and thus the draught increased and the vessel steadied at sea in bad weather; and when nearing port the water could be expelled and the vessel raised to her light draught again. By simple arrangements, these operations, namely, the admission and expulsion of the water, could each be effected in less than five minutes. Such is a general outline of the dimensions and peculiarities of the proposed vessels.

Reverting now to the qualities which the vessels were to possess, it will be found that the first was steadiness in a sea-way. There being no masts or top hamper, and no sail to be carried, it is obvious that, as compared with rigged ships, the stiffness might be diminished with perfect safety.

The author does not ignore the fact that, the wind being favorable, sail steadies a vessel, but he wished to obtain a better result than sail would give; and it should be remembered that the full value of sail (for this purpose) could only be realized with the wind abeam or nearly so. Next, the form of hull might be such as, to a limited extent, to diminish the breadth at the water line without the displacement below; and by admitting water

into the compartments prepared for it, the draught would be increased, and the displacement still further augmented.

The same operation (the admission of water) could be so arranged as in some degree to regulate the position of the centre of gravity of the vessel in relation to the metacentre, and cause these to approach each other sufficiently near to produce steadiness combined with perfect safety. Moreover, the proposed arrangement would give the commander unexampled facilities for regulating the trim of his vessel, to suit varying conditions of loading and weather, and so to produce the best results.

Without going further into the subject, it will be apparent to all, that a large, well-proportioned ship would have less motion in our channel seas than a small light vessel, dancing on the surface; and therefore that, the steamers proposed being (in displacement) about four times as large as those at present employed, greatly increased steadiness and immunity from sickness on the part of passengers might safely be reckoned upon.

The next requirement was, that sufficient shelter and comfortable accommodation should be provided for a large number of passengers. A comparison with the steamers at present employed in the service between Folkestone and Boulogne will illustrate the superiority of the proposed vessels in this respect, for it would be found that the area of the deck and the area of cabin would be double that of the largest of the existing steamers.

The next requirement was that the vessels should have high speed. It will be enough to say that power sufficient has been reckoned upon to give a speed of 16 knots per hour, even in rough weather, so that, even in adverse circumstances, the passage could be made in about 95 min. The time at present allowed, including crossing the Channel, from starting at Charing-cross till the train leaves Boulogne, is about 5 hours 25 min., of which 3 hours and 10 min. is allowed from the time of leaving Folkestone harbor till the time of leaving Boulogne for Paris. On the return journey, the time from leaving Boulogne till the train leaves Folkestone for London is about 2 hours and 40 min. Then, as the proposed vessels would make the passage in 95 min., and with the improved arrangements contemplated at Folkestone, and the steamers being berthed close to the train on the west side of the harbor at Boulogne, 30 min. would be sufficient for embarkation and disembarkation, there would be a saving of from 50 min. to 1 hour and 20 min., thus reducing the journey to and from Paris to about 8½ hours.

The fourth requirement was, that, as compared with the existing steamers, the new vessels should have superior steering and manœuvring powers. The recent opening of the new basin at Boulogne will no doubt do much to diminish the crowding of the tidal harbor, and the works being carried out are designed to improve the channel and entrance. Similarly the improvements which it is proposed should be effected at Folkestone would remove the existing difficulty to the entrance of vessels and their being swung in the harbor; but, nevertheless, chiefly with reference to Boulogne, it is suggested that the machinery of the proposed new vessels should be so arranged that, even in bad weather, they might be readily as well as safely handled.

When the International Communication Bill was before the Committee of the House of Commons, evidence was given, by eminent and experienced men, to prove that the increased size of vessels promotes steadiness in entering a harbor; and having had opportunities of discussing this matter with some gentlemen of experience, the conclusion the author arrived at was that such vessels as those proposed could be safely navigated to and from the port of Boulogne as it exists.

Although about 100 ft. between perpendiculars, they would only be about 70 ft. over all longer than the present steamers, and the increased length would render them less subject to be influenced by a heavy sea, whilst with disconnected paddles, and the starting gear now introduced, by which the engines are handled with such facility and rapidity, the course of the vessels would be more perfectly under control than if dependent upon the rudder alone; but as they could enter and leave the port at high speed, and consequently with good steerage-way, the influence of the rudder would also be augmented.

Inasmuch as the proposed vessels could

make the passage in less time than the steamers at present employed, a foot or more of tide might be saved when arriving on the ebb, and as the existing vessels draw 7 ft. 6 in. to 8 ft., the new steamers might have sufficient water although they drew 8 ft. 6 in.

But, to take the worst view of the matter, let it be assumed that there would arise occasions when the proposed vessels could not safely be taken into Boulogne harbor — what would this amount to? It has already been shown that out of the 365 days in the year, the average number of "days of gales and storms, with heavy seas," is only 29. Let it further be assumed that $\frac{2}{3}$ of these gales are from the westward, then the remaining $\frac{1}{3}$ would not preclude large vessels from entering or leaving, because Boulogne "is sheltered by Cape Grisnez from easterly gales." This would reduce the number to 20, and we arrive at the conclusion that, generally speaking, at a period of the year when the number of passengers is small, there would be a few occasions on which one of the existing packets would be substituted for the large vessel, and, it may be, one or two violent storms when no steamer could cross the Channel.

With disconnected wheels the vessels could be swung in harbor in little more than their own length, but, still further to facilitate their being handled, it is suggested that they should be fitted with steam capstans. Under this head it may also be desirable to mention that it is proposed that the saloon cabins should occupy the middle portion of the vessel. This is not unimportant, because a deck-house, for example, placed aft, would, from the action of the wind upon it in bad weather, render a vessel less manageable in entering a harbor.

The last requirement was that the vessels should be so constructed that the vans containing the passengers' luggage, and a certain number of wagons with merchandise, should be ferried across the Channel without being unloaded. The vans and wagons could be placed by a crane on the main deck, and secured there in a few minutes, but it is suggested with regard to the former that the bodies only should be shipped, and not the frames, wheels, and axles. They could be so constructed that there would be no difficulty in this.

Inasmuch as the weight of luggage and goods carried would vary, it seems to the author that the employment of water ballast would be advantageous, for otherwise the trim of the vessel would seldom be that which was desirable.

The Channel service is said not to be remunerative at present, and the question naturally arises, how will matters be improved in this respect by employing larger vessels?

There are now (between Folkestone and Boulogne) four services per day, viz., a morning or mid-day express boat from each side, and an evening or night boat from each side. This arrangement is no doubt necessary at present, on account of the smallness of the boats employed; but it does not appear that it would be necessary with larger vessels; and the author thinks it could be shown that one boat per day from each side would be quite sufficient for the traffic.

It is proposed that the vessels should be arranged to carry five goods wagons on deck, and, in addition, that they should have hold space for carrying a considerable quantity of merchandise below.

Then as to passengers. At certain seasons they are very numerous, but even during the busiest month, August, it would not be necessary to put on an extra steamer until the traffic had greatly increased; for it will be remembered that it has been shown that the proposed vessels would afford double the accommodation to be found in the largest of the existing steamers, and therefore there should be no doubt of their capacity and fitness to carry, at one trip, as many passengers as the present boats carry at two.

Nor does it appear that the existing double service is more convenient for passengers; for what are the facts? By the night service, the time occupied from London to Paris, and *vice versa*, varies from about 16 to 22 or 23 hours, the majority of the services averaging about 17 hours; and it is not conceivable that any one would subject themselves to the inconveniences of such a tedious journey unless for a weighty reason. This reason is doubtless to be found in the reduced charge; but if the fares be less, the

profit to the carriers must be diminished, and therefore it is not unreasonable to hold that the passenger traffic by the night boats does not pay. But is it not advantageous to the poor class? No doubt it is, and if these were very numerous at any period it might be desirable to run one of the existing small boats for their accommodation. At other times, a considerable number of third-class passengers might be carried by the express steamers at a slightly increased fare, compensation for which would be found in the saving of time and diminished cost of refreshment for the journey.

Assuming that there would always be sufficient accommodation in the mail steamers for the higher classes who prefer, or are compelled, to adopt night travelling, the author concludes that if the proposed vessels had only to make one passage for two of the existing steamers, it would follow that a great economy in working expenses would ensue—more than sufficient, one would think, to convert the alleged present loss into a considerable profit.

It is necessary to have special regard to the protection of the passengers from inclement weather when embarking or landing. This can be readily effected at Boulogne. In the case of Folkstone, the steamers are at times unable to enter the harbor; on such occasions the passengers are compelled to walk to or from the station to near the end of the western pier, exposed to rain and wind; but it is proposed that the embarkation and landing should always take place inside the improved harbor, and directly from the carriages, which would run alongside the steamers, so that the passengers would not at any time be exposed to the weather.

The new steamships would, of course, involve additional outlay; but considering that, one or two of the present vessels being retained, only two would be required, and that after they were built, the majority of the vessels composing the existing fleet might be disposed of, and that, being fast handy boats, they should realize good prices, it does not appear that a very serious addition would require to be made to the capital invested in shipping.

It will be seen that, according to the author's view, it would be better to postpone the establishment of a service at fixed hours until the traffic increased sufficiently to pay for it.

There is nothing startling in the present proposal. It may be said to consist chiefly in a somewhat novel combination of well-tried means to effect a specific result; for, to refer to one prominent feature of the plan, viz., the occasional use of water ballast, numerous vessels are daily at work which have their draught thus increased at pleasure, so as to bring them into good sailing trim. The peculiarity of the case under consideration is, the application of this system to secure the comfort of passengers at sea, and at the same time to overcome the difficulty arising from the deficiency of depth of water in the harbors.

Before concluding, one or two points remain to be noticed. It is obvious that such a system would not be applicable for long voyages; that when in rough weather the vessel was put down in the water to steady her, in order to maintain the same speed, additional power would have to be developed by the engines, and thus the consumption of fuel would be augmented. On examination, however, it will be found that the increased working charge for so short a distance is not worth consideration. During fine weather, of course, the vessel would be steady at her light draught, and therefore it would only be occasionally that she would be immersed to her deep line.

There would be a substantial increase in the first cost of the machinery, but, on the other hand, the engines could be worked more expansively, and therefore economically, when the vessel was at light draught.

It may occur to some that the varying immersion of the paddle wheels would be a difficulty, but it should be borne in mind that the diminished immersion of the floats at light draught would not be inconsistent with the decrease in power required to drive the vessel in that condition.

One word more. The quantity of water to be admitted and expelled for the purpose of bringing down the vessel from light to deep draught would necessarily be considerable; but it has been ascertained that 4 centrifugal pumps, and those not of extravagant dimensions, would suffice to effect the expulsion of the whole in less than 5 minutes.

ON THE FUSION OF WROUGHT OR FIBROUS IRON IN THE LARGE WAY IN REVERBERATORY FURNACES.

By JAMES D. WHELPLEY, M. D.

Certain experiments upon the fusion of wrought or fibrous iron in the large way in a reverberatory furnace were made at the experimental furnace works of Messrs. Whelpley & Storer, at South Boston, Mass., during the month of December, 1870.

It is well known that wrought or fibrous iron, made from pig iron by the common process of puddling or decarbonization, cannot be fused by the heat usually attained in reverberatory furnaces. It has been fused in crucibles or melting pots, such as are used for steel making, but not to my knowledge when laid uncovered upon the open hearth, or in large quantity, or without the assistance of a fusible carbonized iron as a flux.

By the elaborate experiments of Bessemer in England, it has been shown that the intensity of furnace heats can be raised to the melting of wrought iron by adding 20 lbs. to the sq. in. of common atmospheric pressure in a closed furnace constructed for the purpose.

For the perfect fusion and casting of large masses of fibrous iron it is necessary to create and sustain a temperature much above the original melting point. The bath of metal must retain the fluid condition during the process of casting.

A bar of fibrous iron heated to whiteness and exposed in a hot furnace to a blast of air directed upon its surface, burns and melts rapidly into black oxide or "cinder." It is not known what proportion of free oxygen in the mixed gases of a furnace, will cause the oxidation of fibrous iron; but it is certain that oxide of carbon, or hydrogen, must be present in excess to prevent it, and when steel containing only a fraction of 1 per cent. of carbon, or iron of a fibrous character containing only small quantities of carbon and silicon, are to be melted, the free oxygen present should be inappreciable.

In the furnaces constructed and used by Messrs. Whelpley & Storer, a cloud of finely pulverized bituminous coal is burned in the manner of a gas jet directly over the charge in the body of the furnace. The stream of pulverized fuel is projected horizontally through the furnace from the mouth-piece of a blow-pipe of 2 or 3 in. calibre. This blow-pipe jet supplying an impalpable dust of carbon, carrying less air than is needed for its complete combustion, passes first through a small gas flame furnished by an ordinary brick generator. A blast of hot air (500 deg. to 700 deg. Fahr.) is projected into the furnace through a separate pipe in conjunction with the jet of carbon. Combustion is completed in the body or oven of the furnace, which is constantly filled with fine floating carbon and gas in process of combustion. The pipes supplying fuel and hot air are governed by valves. The sole of the furnace is a long oval, 7 ft. by 5 in dimension, covered by an oven-shaped roof with uniform elliptic, hollow lines.

The first experiment made with this furnace gave a heat equal to that of an ordinary puddling furnace in one hour and a half from the time of lighting up. The hot air blast was then applied, and in another hour steel melted freely upon the hearth *without cover and without oxidation.* In four hours' time the heat of the furnace, using 160 lbs. per hour of extremely fine dust of bituminous coal, was such as to melt in 15 min. a charge of 60 lbs. of common merchant bar iron, laid cold upon the hearth. The effect of the furnace was then tried upon cold Bessemer rail ends, which were easily fused, 110 lbs. melting freely in 20 min. Common iron rail ends melted easily.

As it was now evident that the furnace would bear severer tests, a new hearth was made of the best quality of sand, suitable for steel melting.

After 5 hours of heating, the total consumption of fuel being 200 lbs. per hour, 600 lbs. of scrap boiler plate iron was charged in cold, and without cover. The entire charge came to a perfect fusion in 55 min. *without oxidation.**

Repetitions of the experiments, with larger and smaller charges, have constantly given similar results. The pro-

* In furnaces used for the manufacture of "mild" steel, or "homogeneous metal," the charge should be brought to a white heat before placing it in the furnace. The experiments above described were only made as tests of the heating power of the furnace.

cess of tempering the bath for steel of different grades is well known, and does not need to be described in this notice.

During the melting of fibrous iron there is certainly a free absorption, but probably not any decomposition of carbonic oxide by the metal at the time of fusion. Unless certain well-known precautions are taken the cast ingots are filled with bubbles of a non-oxidizing gas; but there is no evidence to show that any carbon from the gas enters into combination with the iron. I am inclined to believe that the fusion is favored by the free absorption of gaseous oxide (C O). The uncombined carbon, usually present in wrought iron in fractions of one per cent., probably takes the form of combined carbon during the fusion.

The experiments made in December were definite, and they are conclusive in regard to the fusion of wrought iron in quantity, without the addition of carbonizing materials, or covering to prevent oxidation. Scientific metallurgists will draw their own conclusions.

The metal produced by this cheap and simple method is of exceeding tenacity after condensation by hammering, and has all the characters of "mild" steel, or "homogeneous metal." It may be bent cold in large or small bars, and has, when cold, the qualities of the finest known brands of bar iron.

The temperature produced and sustained in so large a furnace, with so small a consumption of fuel, with the continued presence of a non-oxidizing flame, may be accounted for by supposing that the intensity of heat increases in some geometrical ratio of the quantity of carbon burned in a given time in a given space. Other explanations have been offered by scientists. Under all hypotheses, we know that the rapid and perfect combustion of solid carbon in particles microscopically small, should give higher temperatures than the combustion of gaseous carbon in any shape.

The highest working temperatures hitherto attained in reverberatory furnaces have been generated by the well-known process of Siemens now used in the manufacture of steel. The gases liberated by the slow combustion of bituminous coal in large generators furnished with a limited supply of air, are conducted and cooled in iron pipes which lead them into a reverberatory furnace, where they are turned in combination with a hot blast. It is not necessary to urge that the combustion of the cooled oxide of carbon thus produced, will not give an equal degree of heating effect with the combustion of an equivalent of solid carbon. The first equivalent of heat in the Siemens method is sacrificed in the production of gas. The second equivalent only can be utilized in the furnace. If the same quantity of carbon can be burned to carbonic acid in an equal or smaller space and in the same time, the first equivalent is utilized in conjunction with the second, giving of necessity a higher effective temperature. The hot blast is certainly indispensable, and in all well conducted establishments where there is a proper regard to economy, it will be produced by the utilization of waste heat.

In the furnaces constructed and used by Messrs. Whelpley & Storer, for the burning of pulverized carbon, carried by an air blast into the furnace, the intensities of heat generated by the blow-pipe flame, have been limited only by the fusibility of the brick work composing the sides and cover of the furnace. It is probable that in a small fire-box composed of less fusible material, let it be for example quick-lime, temperatures may be obtained by the burning of carbon dust in conjunction with a highly heated blast of atmospheric air or of oxygen which will fuse, not only platinum but the purer kinds of silicious minerals.

The mechanism for the pulverization of the coal employed in this process is to the general public and the engineering profession a very novel invention, although it has been in practical use in New England since 1863. A small iron drum or cylinder about 12 in. interior diameter and length, carries internally a steel axis furnished with paddles of soft steel, which move at the extremities of wrought iron arms without friction against the interior of the drum, at the rate of 10,000 per min. Small coal, bituminous slack, is fed automatically into the side of the drum about the shaft, and being reduced to dust by the violent rotatory action of the paddles, is drawn out by a small exhaust fan in a case of its own, which forms a part of the machine, and projected by the same through a 2 or 3 in. pipe of sheet iron into the furnace. The finely comminuted

fuel takes fire at the instant of entering the working chamber of the furnace. A force of 1-horse power is required for the comminution and delivery of 150 lbs. an hour of bituminous dust. The gas generator will consume at the same time about 50 lbs. an hour in anthracite slack. The hot hot-air blast is furnished by a set of cast-iron pipes in the stack. The generator and hot-air pipes are supplied with air from a small Sturtevant fan.

The fineness of pulverization is excessive, and can not be attained by any other known apparatus. It is apparently accomplished by the mutual attrition of the particles of coal, as there is no friction of iron surfaces or grinding action by the pulverizer. A cubic inch of coal presents 6 sq. in. of surface to the action of heat. The distillation of gas and combustion of the solid coke of bituminous coal in the lump is consequently slow, and subject for a long period of time to the causes of waste. After passing through the above-described air-mill of Messrs. Whelpley and Storer this same bulk of carbon will have its surface extended from 6 sq. in. to 40 sq. ft., and a considerable portion will have been so finely divided as to present 200 sq. ft. of surface to the cubic inch of solid.

Instantaneous and perfect combustion, with a proper supply of air, for carbon in this condition, is a matter of course, the gas and coke burning in swift succession. An expanding flame is produced of extreme and almost uniform intensity. Scrap-rail piles heated in this flame lose only $1\frac{1}{2}$ or at most 2 per cent. of their weight. Pig-iron, puddled for bar, instead of losing, gains considerably in weight of metal through the reduction of metallic iron from the cinder and ore lining the furnace. The metal heated and worked under such a fire is free from particles of carbon and cinder, the generator sending over only a small volume of hot gases, and the entire body of ash passing with the draft into the ash-pit beyond the flue bridge. The texture of the rough or muck bar thus produced is uniform, whether made from scrap or pig metal, as there is no imperfection caused by unequal heating, oxidation, or ash.

I have forborne to enter upon details in this communication, as my purpose has been only to record the facts above stated. The use of carbon in fine dust mingled with a just proportion of atmospheric air has been long since regarded by scientific engineers as the theoretically perfect method of combustion. The problem has been to construct and apply a mechanism by which it should be made practicable.

LIGHT BOILERS.

From "The Engineer."

One of the great mechanical wants of the age is an extremely light steam generator of great power. The nearest approach to such a thing in existence is the boiler of a steam fire-engine—such, for example, as those made by Messrs. Shand & Mason and Messrs. Merryweather. But steam fire-engine boilers, as hitherto constructed, are unsuitable for constant hard work continued without intermission for days or weeks. Why want of endurance is a necessary accompaniment of their construction we shall explain further on. It is probable that the most efficient steam generator ever constructed has weighed, without its contents, little less than 56 lbs. for every horse-power indicated which it could develop—that is to say, a boiler weighing 25 cwt. might probably drive an engine, using steam economically, up to 50 indicated horse-power. If such a boiler could be so constructed that it would be suitable for use at sea a great advantage would be gained. For numerous other purposes, extremely light boilers are wanted. The production of a boiler which would give 1 horse-power of steam for each 20 lbs. of its own weight would indeed totally revolutionize many branches of engineering. Is it impossible to produce such a boiler? We think it is not; and we propose to state here our reasons for thinking it is not, and to indicate the nature of the principles which must be observed in the attempt to produce extraordinarily light boilers which can be worked safely and efficiently for many days and weeks at a time.

And first, we must see on what the weight of a boiler depends. In all cases

this is determined by the extent of heating surface, the pressure at which the boiler is worked, and the way in which the strains to which the boiler is exposed are dealt with. In some cases, as in egg-end boilers, the external shell forms heating surface. In others, as locomotive boilers, the heating surface exists independently of the shell; in others, as the Cornish boiler, the heating surface is partly made up by the shell and partly by special surfaces — flues — introduced as such. In all these boilers the weight is determined by the area of heating surface and the thickness which it is necessary to impart to the metal to make it resist the bursting strains to which it is exposed. The heaviest form which heating surface can assume is that of a flat plate, because it must be stayed to enable it to resist pressure. The lightest form is that of a tube exposed to external pressure, and the next lightest is that of a tube exposed to internal pressure. Spheres would be stronger than tubes of similar diameter by 2 to 1, but spheres present certain practical difficulties which render them unsuitable for the generation of steam; we are, therefore, driven the moment we attempt to produce a very light boiler, to the use of tubes. But whatever form the boiler may assume, it is certain that under existing arrangements it is essential that about 2 sq. ft. of heating surface should be provided for every indicated horse-power of steam required. In other words, about 2 sq. ft. of heating surface will evaporate not more than 30 lbs. or 35 lbs. of water per hour, with any approach to economy. The external surface presented by a tube increases in the precise ratio of its diameter. Its power to withstand bursting or compressive strains diminishes in the same ratio. It follows as a consequence that of two tubes exposed to the same strains, and presenting one twice the area of heating surface of the other, the larger tube must weigh four times as much as the smaller, for the area of metal in the large tube is twice as great as that in the small tube, and it is also twice as thick. It is, therefore, evident that the smaller we can keep our tubes the less will be the weight of a given area of heating surface, in about the ratio of the square of the diameter of the tubes. Consequently any extremely light steam generator must be mainly composed of very small and thin tubes. This is the principle adopted in the construction of the boilers of all steam fire-engines. There is a practical limit to the use of this principle which we shall consider in a moment. It may be taken as proved that it has been reached in the best modern steam fire-engine. If we want anything lighter still, or a boiler which, without being lighter, shall possess considerable powers of endurance, we must modify very largely the present system of working.

We have thus far seen that but one method of giving extreme lightness in a steam generator is available, namely, the reduction of the diameter and thickness of metal of the greater or lesser number of tubes of which such a boiler must of necessity be chiefly composed. We have now to consider another method of attaining the same end. This consists simply in augmenting the efficiency of heating surface. If we can make 1 sq. ft. of heating surface do the work of 2, then we can reduce the weight of our boiler by, roundly speaking, one-half; not quite half, perhaps, because the weight of the external shell affording steam and water space will be, to a limited extent, independent of the weight of the heating surface. It is in this direction, and in this direction alone, that we can find any prospect of making boilers lighter than the lightest now in use.

The practice of modern engineers tends to the development of very moderate degrees of heat in large furnaces and the extension of heating surface. In designing a very light boiler we must perforce adopt a totally opposite system. We must use a very intense heat, and reduce the surface intended to absorb it. Engineers adopt extended surface simply because it has hitherto been found essential to durability. Its absence in steam fire-engines explains that want of endurance alluded to at the commencement of this article; but we think it may be shown that, after all, extension of surface is but one way of obtaining the desired end, and that not the most efficient under any circumstances. If a portion of heating surface, such as a fire-box crown sheet, or a tube, is exposed to a very intense heat, it is rapidly burned, loses its "nature," and becomes brittle and rotten. But why? Simply because the temperature of the metal has been permitted to

become too high. In locomotive practice it has been found that some fire-boxes rapidly wear down to a thickness of about ¼ in., but beyond that point the waste becomes almost imperceptible, and American engineers, acting on this fact, often start with plates very little over ¼ in. thick, very closely stayed. It admits, we think, of proof that if any portion of heating surface can be kept so thin that the temperatures of the outside and of the inside of the metal are nearly identical, and little in excess of that of the water with which one surface ought to be in contact, no burning or wasting of the metal will take place. But this condition cannot be fulfilled in ordinary steam boilers. In such a generator as that used by Messrs. Shand and Mason, for example, we have small and thin tubes exposed to a very intense heat, which is as it should be ; but, on the other hand, the quantity of water contained in the boiler is so small, and the generation of steam so rapid, that it is certain the tubes can contain nothing but a species of froth. Steam and water cannot be in the same place at the same time, but the instant water reaches the tubes it becomes steam and repulses water ; and it is by no means impossible that under the conditions the relative time of contact of steam and of solid water with any portion of the tubes is measured approximately by their relative volumes. Instead of entering solid water, the heat passes from the furnace through the tube walls to a mixture of steam and water infinitely less efficient in keeping the metal cool than water alone. The remedy for this consists, not in reducing the temperature of the furnace, but in not permitting any steam to be generated in the tubes, which would then be filled with water only.

In the next place, it is by no means certain that heat is communicated to the heating surface of the best boiler in existence in the best possible way. If, instead of the products of combustion being allowed to flow rapidly *along* the surface to be heated, they were concentrated and compelled to impinge forcibly on that surface, their efficiency would, we have every reason to think, be promoted. The heat given out by the side of a gas jet, for example, is as nothing compared to heat imparted by the point of the jet violently impinging on a surface. This fact is well understood by engineers, and great care is taken in most instances to obviate impingement as effectually as possible. But impingement is only objectionable because the plates of the boiler are thick, and the water can be easily driven away from them. If the plates were very thin, and the water in close contact, impingement could do no harm.

Putting all this reasoning together, we arrive at the conclusion that an extremely light and efficient steam generator can be made in somewhat the following way. The heating surface must consist of tubes of very thin rolled copper not more than ½ in. in diameter. These tubes will be so disposed as to connect 2 water chambers, both of which, with the tubes, must be kept quite full of water. With one of them will be connected a receiver and separator, into which a regulated quantity of water will flow constantly from the generating tubes. The formation of steam in the tubes must be prevented as completely as possible, and to this end the pressure in the tubes must be much higher than that in the receiver and separator. A pump must be provided by which the water will be kept in constant and very rapid motion through the tubes. Its work will consist in overcoming the frictional resistance of the water; but it is essential that the velocity of the water must be so great that any, even the smallest bubble of steam, or any even the smallest quantity of deposit, may be instantly swept off the metal, which must under all circumstances be constantly kept in the closest possible contact with solid water.

The arrangement of the tubes should be such that they may be exposed to the direct impact of a current of ignited gas generated in a suitable furnace and forcibly driven through the narrow spaces intervening between the tubes by a powerful blast. The heated water discharged into the separator or receiver will of course in part flash into steam for the supply of the engine, and in part be returned, to be again propelled through the tubes in a way which we described more particularly in an article which will be found at page 414 of our last volume. In the absence of direct experiment it is impossible to say how much steam can be generated in the hour by a single foot of heating surface ; but if we bear in mind that the metal would be extremely thin,

and in close contact—due to the action of the blast—on one side with a body of flame heated to at least 2,000 deg., while on the other, it would be in still closer contact with a hurrying body of water heated at most to about 300 deg., it will, we think, be freely admitted that, whatever its faults may be, such a generator would far transcend in efficiency, weight for weight, anything now in use; nor does it appear that any difficulties would be encountered in the construction of such a generator which could not be overcome by modern engineering skill.

THE SIEMENS REGENERATIVE FURNACE.

From the "Bulletin of the American Iron and Steel Association."

At the last meeting of the Cleveland Institute of Engineers, held at Middlesbrough, a paper on the above subject was contributed by Mr. Healey of Glasgow, in which he states that as he had had charge of the erection of these furnaces at a number of works in England and Scotland, during a period of six years, he trusted that the knowledge he had acquired of the theory of the system, and also its practical application, would make the paper useful and interesting. He considered that it would be tedious to go into the details of his experience generally, so he had selected the Blochairn Iron Works, Glasgow, as the basis of his paper. The author states that the application of the principle at the Blochairn Works is the most extensive in Great Britain, and, therefore, the facilities afforded for ascertaining practical results are very great, and such results may be set down as reliable in every respect. There are at present in the new works, 16 heating furnaces, and 24 double puddling furnaces; and 35 puddling, and 4 heating furnaces are to be built in the old works, part of which are now in course of erection, making a total of 20 heating furnaces, and 59 double puddling furnaces. The gas is applied at present to the new works from 48 producers, and a second arrangement is more than half built for the old works, which, when completed, will be connected to the first, making a total of 96 producers. The gas producers may be constructed of various forms to suit the fuel to be used, which may consist of any carbonaceous substance; coal being the fuel chiefly used in England and America, wood in France and Spain, peat in Italy, sawdust in Sweden, and lignite in various parts of Germany. The coals are delivered by canal at one end of the producers, and wheeled from the quay to the several coal bunkers. Mr. Healey mentions that small coal or slack, well washed, makes better gas than round coal, but in working with the former it is necessary to keep the fuel on the grate much thinner than with the latter.

It is important that a continuous pressure be maintained in the producers and flues to prevent any indraught of air. Where the producers can be built on a much lower level than the furnaces, this is at once obtained; but generally the furnaces and producers stand on about the same level, and in such cases the best plan is to elevate the cooling tubes, as by this means a siphon is formed, in which the limbs are of equal length, but one is charged with heavier gas than the other. This pressure is sometimes obtained by using jets of steam under the producer grate. At Blochairn the top of the producers is 3 ft. below the mill floor, and consequently there is always a good pressure throughout. It had been argued that this siphon action wastes a certain amount of heat, but this is not the case, as the temperature of the gas entering the chambers regulates to a great extent the temperature of the waste gases passing off to the chimney flue; the cooling tubes, on the other hand, have the advantage of condensing the vapor that may be carried off from wet fuel, which would otherwise oxidize the metal in the furnace. The heat from the cooling tubes will be economized for heating the water for the boilers, by making each of the horizontal tubes with an outer belt, four feet wide, near to the upcasts, between which and the tubes the water may circulate. The heat at the upcast end of the tubes is about 1,100 deg., and the application of this plan will insure a considerable saving of fuel at the boilers. The producers are generally arranged in

groups of four, the gas from each group leading into one of the upcasts. At these works three such groups are built together, forming one wing of a division, the cooling tubes from which are attached to the left side of a main collecting tube, while three similar tubes collecting the gas from another wing, are fixed on the right side, and the gas from six groups is thus conveyed through the main tube across the canal, a distance of about 176 ft., to the downcast, which, in its turn, is connected to the main gas flues leading off the furnaces. The gas produced in the manner described is the fuel used in the furnaces. The furnace is constructed, as its name implies, with regenerators, which consist of four chambers built in pairs under the furnace, one of each pair being for gas, and the other for air. These chambers are built with fire-bricks, spaced so as as to allow sufficient flue room, and the courses are set so that the bricks of one course of regenerators cover the spaces of the next, thus causing the currents to impinge freely upon the bricks, by which means a large surface is exposed for taking up the waste heat of the furnace.

The regenerators vary in size according to the work to be done, but taking the products of combustion of 1 lb. of coal as possessing a capacity for heat equal to that of 17 lbs. of fire-brick, that quantity of regenerators in each pair of chambers would be sufficient theoretically for each pound of coal converted into gas ; but about four times as much regenerative power is practically required, as only about one-fourth of the regenerators are heated to the full temperature of the heat passing down the ports. The best size and arrangement of bricks for the regenerators has been determined by a series of experiments; but no definite rule can be given, as various circumstances have to be taken into account in designing a furnace, such as temperature, degree of steadiness required, and period between reversals, every application requiring special combinations to adapt the principle. The gas flame being purer than the flame in an ordinary furnace, does not cut the brickwork ; hence, if the best material be used for the upper parts of the furnace, the repairs are very light. When it is considered that a mass of metal has to be heated to a temperature of 2,000 deg. by a flame of, say 3,000 deg., it is evident that the waste heat will be about 2,000 deg., most of which is economized in the regenerative furnace. The means at command for regulating the flame is in itself a great advantage, as at any moment the flame may be changed to suit any requirement, and may be of any length, and either reducing or oxidizing. At Blochairn the nearest furnaces are at a distance of about 300 ft. from the gas producers, which allows the operations in the works to be carried on with much greater cleanliness than usual. Many persons have been misinformed as to the cost of these furnaces, and for the guidance of such, he remarks that at the new works referred to, where they have been erected in preference to all others, and are capable of producing about 2,000 tons of iron, in the shape of plates, angles, bars, and rails, weekly, the cost, without royalty, has been no more than would have been the case if the old kind of furnaces had been laid down, partly owing to the great saving of room ; the space usually occupied by coal bunkers and fire grates not being required under the main roof. In working these furnaces, the valves are reversed at regular intervals of about 30 min.; the regularity is of greater importance than the frequency of such reversals, for this reason, that if the hot waste gases impinge for a longer time on one side of the butterfly valves than on the other, they are liable to twist, and so will not bear truly on their seats in the reversing valves, and the regenerators are also heated unequally by the same cause, and in such a case the furnace works hotter at one end than the other, which however, is soon set right by care in reversing. The author states that a charge may be left in one of these furnaces an almost indefinite time without wasting to any great extent. Instances have occured under his own notice, of charges of about 5 tons being left in the furnace for 30 hours, and after being heated ready for the rolls, the heat has been let down, and got up again, when the rolls are ready for work ; this process of getting up the heat, and letting it down, was repeated thrice on one occasion during a period of 30 hours, and the charge was afterwards rolled into iron of the best quality, the length of time during which it was exposed to the gas flame having had no perceivable detrimental effect upon it.

The heating power of these furnaces is about 12 tons of piles in 12 hours. The best material for the exposed parts of these furnaces is made from fire-clay, found at Glenboig and Gartcosh, near Glasgow, but any good fire-brick will answer for the lower parts. He then touches upon the subject of the application of Siemens' principle to puddling, and says that recent results obtained at Glasgow have proved that the advantages of the regenerative gas furnace for puddling are very important, and although many difficulties have presented themselves in the various details, they have been overcome. Comparing the results as to yield of Siemens' furnace, with results of an ordinary furnace, with, say 8 per cent. of waste, there is something very striking. In an ordinary furnace there is a great waste of iron, caused no doubt by the free oxygen present, which burns a part of the iron, and thus the increased temperature required at the time of balling the iron is obtained at the expense of this waste, and it is doubtful whether the heat required at this stage of the process could be obtained in an ordinary furnace without thus using a portion of the iron as fuel. When the iron is being puddled the heat is comparatively low, but when it comes to "nature" the heat requires to be increased speedily so as to completely weld the particles together. This change of temperature is obtained in the gas furnace in as little time as it would take me to describe it, and much time is saved in the manipulation of the valves over that required to obtain similar results in the old way. The work that can be done in a puddling furnace of this description is 5 charges of 10 cwt. each per day, besides scrap balls; and when working with plate metal and gray pig the men perform the work in about 10 hours, while with full charges of gray pig $10\frac{1}{2}$ hours is required. The improved quality of iron produced in these furnaces is attributed to the greater purity of the flame, and also to the great heat at which the furnaces may be worked, as it is well known that when the iron has come fully to the boil, if the furnace is kept as hot as possible, the cinder is more liquid and less liable to be lapped in the balls when under the hammer. The ports of these furnaces should be built of silica bricks from the floor line to the top of the mixture, although Glenboig or Gartcosh bricks are found to stand very well for the crowns, jambs, and port ends of the regenerators. It has been practically proved that there is a considerable saving in the cost of fuel, as fuel of inferior quality can be used in the gas producers such as could not be used in an ordinary furnace; and the weight used being also much less, the actual saving may be safely put down as from 30 to 50 per cent., varying according to the work for which the furnace is adapted. The most important feature in economy is the fact that at least 50 per cent. of the usual waste of iron in the heating furnaces is saved, and that in puddling, the yield is generally equal to the weight of the metal charged. With regard to general convenience and facility of operation, he instances that some time ago Scotch workmen intimated that they would not work these furnaces; now, however, that such furnaces are actually at work, they prefer them, and on a late occasion, when a part only of the Blochairn furnaces were to be worked, they requested the gas furnaces to be lighted in preference to the old ones. Mr. Healey states that the heating furnaces which are now being built by the Britannia Iron Co., Middlesbrough, are somewhat similar to those at the Blochairn Iron Works, and as soon as they get fairly to work, he expects other firms in the district will perceive more clearly the numerous advantages to be derived from this application.

Professor Zollner has published the result of some experiments made upon the spectrum of the aurora borealis last October. The conclusion which he draws is, that if the light arises from incandescent gas particles of our atmosphere, the temperature at which it takes place must be very much lower than is required to render the same gases incandescent in Geiseler's tubes, so that the region in which the phenomenon occurs must be of extreme tenuity.

The Act of 1864 for the testing of chain cables and anchors, expires in 1872, and the Board of Trade have a bill in preparation, not merely to renew but likewise to amend some of the provisions of the Act.

BURNT IRON AND BURNT STEEL.*

By MR. MATTIEU WILLIAMS.

From "Ryland's Iron Trade Circular."

After quoting the attempts already made to explain the chemistry of "burnt" iron and "burnt" steel, Mr. Williams referred to the practical importance of obtaining some laboratory method of readily determining whether the brittleness or rottenness of a given sample of manufactured iron was due to original impurities of the raw material or to the fault of the workman who had burnt the iron in forging it. The conflicting and unsatisfactory theories of the chemistry of the changes effected in burning at first stood in the way of his attempts to solve this problem, when an accident revealed the true theory, and at the same time suggested the desired practical test.

Two samples of borings, marked "Steel A" and "Steel B," were sent to him to analyze, but he found that one of them contained no carbon and the other a mere trace; that consequently they were not steel, but both were iron. A difference in the behavior of the samples when the acid solvent (nitric acid diluted to the the specific gravity of one-half) was first applied was observed. Sample A rendered the acid dark-colored and turbid ; sample B presented the usual appearance of good iron in the course of solution. The darkness or turbidity of A disappeared when the solution was complete, and no insoluble residue was left behind. Further examination proved that the peculiar appearances presented by A were due to the presence of minute particles of oxide of iron intermingled throughout the sample; and upon further inquiry it was ascertained that the marking of the samples as "steel" was merely a trick of an over-sharp, excessively "practical" man, who thought the chemist could not distinguish borings or filings of steel from borings or filings of iron. Sample A was from one side of an armor plate which had been burnt, and B was from the opposite side of the same plate, but which had escaped the burning. Further experiments were made with samples of burnt iron of different degrees of rottenness, ranging from barely damaged specimens to the extreme case of burning presented by the contents of the Bessemer converter before the spiegeleisen is added. In all these, free oxide of iron was found not merely on the surface, but *diffused more or less completely throughout the substance of the iron.* It was further found that the simple test of adding borings of such iron to nitric acid of specific gravity one-half affords, after a little practice in recognizing the peculiar appearance presented by the suspended black particles that are suspended by the effervescence, a reliable and very ready and rapid method of detecting the burnt iron, as the silicon and graphite of cast-iron or pig-iron produce a turbidity and darkness which may be mistaken for the appearance due to oxide. The dark color produced by the combined carbon of steel is distinguishable by its permanency. Burnt steel was next examined. This presented no indications of the presence of free oxide, as was theoretically expected ; previous observations and experiments having shown that the presence of combined carbon protects iron from oxidation by heat.

What, then, is the action of burning in the case of steel? Mr. Williams described a number of experiments wherein he subjected bars and plates of steel of known composition to the action of furnace heat, for periods varying from a few hours to four days, and found that in every case the quantity of carbon was diminished in proportion to the period and severity of the exposure; that this removal of carbon was not confined to the surface, but, in lesser degree, it occurred throughout the substance of the steel. When steel was burnt there was always a loss of carbon.

From these facts he inferred that the damage done to steel by burning is due to the oxidation of the carbon. It is well known to practical men that when steel is thus burnt, by raising it to a yellow or white heat, and then suddenly cooling it, the "grain" exhibited by fracture is much coarser than in another piece of the same bar which has only been moderately heated. This coarse grain is usually called

* Extracts from a Paper read before the London Chemical Society.

crystalline; but Mr. Williams controverted this idea of crystallization, as the facets of the grains, when examined with a hand magnifier, exhibit concave and convex faces, rather than the plane surfaces characteristic of crystallization. He suggested that the structure of burnt steel would be more correctly described as "spongy" than as crystalline, and he attributed this spongy structure to the evolution or suppressed occlusion of carbonic oxide, and possibly of oxygen also, which have been suddenly arrested in the passage through the metal, and thus existed as minute bubbles in the steel.

To those who are unacquainted with the researches of Deville, Troost, and Graham, this idea of oxygen penetrating the substance of solid bars of iron and steel, and oxidizing the iron or carbon of their interior, may appear rather startling; that the researches of the above-named philosophers have proved conclusively that gases pass through highly heated iron and steel with a facility which may be rudely compared to the passage of water through blotting paper; that certain gases become "occluded," or hidden, in wondrous quantities within these and other metals, and there retained in mysterious imprisonment, to be again set free under varying conditions of temperature and pressure. This being the case, the difficulty of conceiving the internal oxidation of iron and carbon, and the internal formation of carbonic oxide, is removed. When the steel is highly heated, and the oxidation of its carbon, and the consequent evolution of carbonic oxide is rapidly proceeding, it is easy to conceive that a sudden suppression of this action, by plunging the steel in water, may fix the gases in the act of passage; and, while still in the gaseous condition, this would produce the spongy state, and exhibit the concave faces of the minute air-bubble cavities.

The paper concluded with a promise of further communications to the Society on the subject of the so-called "crystalline" and "fibrous" structure of iron, the writer regarding the appearance and mechanical peculiarities usually ascribed to crystalline as the result of the occlusion, exclusion, endosmosis, and exosmosis of gases in the metal, and its consequent spongy structure; and the "fibrous structure of iron to the rolling down or consolidation of this spongy structure, and the welding up of its pores."

ON THE COMMERCIAL ECONOMY OF SEVERAL TYPES OF MERCHANT STEAMERS ON SOME OF THE PRINCIPAL LINES OF STEAMSHIP TRAFFIC.

By WALTER C. BERGIUS, Esq.

From the "Journal of the Society of Arts."

There has been such extraordinary progress made within the last few years in the powers of locomotion, and the commercial economy of steamships, that the economical conditions of the carrying trade at sea have been most materially changed, and are still changing in favor of improved and well-managed steam carriers *versus* sailing vessels.

For the purposes of comparison I give below a table showing the annual performance and the annual cost of 5 different merchant steamers, each representing, as to size, speed, and the local and economical conditions of its traffic, a distinct type of ship.

To compare these 5 types of ships upon fair and equal terms, I have omitted in their cost per annum the expenditure in port dues and pilotage, as well as the risks of interruption of traffic by accident which would not be covered by insurance. The management account, which is so extremely different in different undertakings, and has really little to do with the engineering question of commercial economy, has also been omitted—so that the three items constituting the annual cost of the vessels are only crew and provisions account, coal and engine store account, interest, depreciation, wear and tear, and assurance account; the latter figure being charged at an equal rate or percentage of value against all the ships except the "foreign coaster," which has to carry $\frac{1}{2}$ more under this

head, as she trades in a locality where accidents to her machinery involve at once a voyage, perhaps under sail, to a repairing port not situated on her line.

The figures given for the annual performance of the 5 ships are likewise computed in such a manner as to bring them upon a fair and equal footing for comparison. As we wish to consider only the engineering question of commercial economy, we must assume the ships to be fully employed all through the year, omitting to take into account any loss of time resulting in one or other of them through ice in her ports of sailing, or through delays arising from extraordinary repairs which are not made good by the underwriters. We must further assume the 5 ships always to have full cargo, deducting, in computing the dead weight carriage, the amount of coal carried for the particular trade the vessels are engaged in, and fixing the draught and dryside in accordance with the scale of the Liverpool Association of Underwriters for the Protection of Shipping.

The performance of the 5 ships is given in carriage units, called "ton-miles," computed in an analogous sense to "train-mile" in railway terminology. A ton-mile is the performance accomplished in carrying one ton of dead weight for the distance of one nautical mile; therefore, if a ship carries 200 tons dead weight, besides her coal, upon load draught, and runs a distance of 35,000 nautical miles per annum, her total annual performance as a freight carrier is 35,000 $\times$ 200, equal to 7,000,000 ton-miles.

Annual Cost and Annual Commercial Performance of five Merchant Steamers recently constructed.

TYPE OF SHIP.	Annual cost of ships.				Annual commercial performance of ships.			
	Interest, tear and wear, maintenance, and insurance accounts.	Coal and engine store accounts.	Crew and provision accounts.	Total annual cost of ships.	Dead weight besides coal.	Mileage per year.	Commercial performance per year.	First cost of commercial performance.
	£	£.	£.	£.	Tons.	Naut'al Miles.	Ton-miles.	Pence per ton-mile of carriage.
1. German Ocean water ballast collier..	3,100	540	1,350	4,990	1,000	38,000	38 millions	0.031 *d.*
2. Baltic goods carrier..................	4,500	2,450	1,850	8,800	1,000	37,000	38 "	0.057 *d.*
3. Home trade grain carrier	1,500	520	1,250	3,270	350	38,000	13¼ "	0 058 *d.*
4. Foreign coasting steamer...........	3,500	4,750	1,550	9,800	500	38,000	19 "	0.124 *d.*
5. North Atlantic mail steamer	18,000	8,400	1,300	34,700	1,200	42,000	50½ "	0.165 *d.*

A few general data about the economical conditions of the service of the 5 ships above mentioned should be added to the table.

1. The German Ocean water-ballast collier trades under the advantage of the cheap coal of a coal-exporting port, and carries, like the Baltic goods carrier and the home-trade grain carrier, its own coal for the home voyage on leaving the United Kingdom. The 38 millions ton-miles of commercial performance, which she can do at a cost of $4,990, are not realized in her service, as she makes her own trips in water ballast only, so that, in the present practice, one ton-mile of coal carriage costs 0.062d.

2. The Baltic goods carrier is proportionately very expensive in her coal account, as she has common engines and a common condenser also, although of recent construction. She goes at a speed of 10 knots in service.

3. The home trade grain carrier, on account of her small tonnage, is expensive in crew and provisions account, and has dearer fuel, as she trades from Channel ports.

4. The foreign coasting steamer pays £3 per ton for her coal, and, as she has

some 35 per cent. of her value charged against her annually, by way of interest, depreciation, tear and wear, and maintenance and insurance account, on account of the excessive cost of repairs in her service, her performance as a freight carrier is necessarily very expensive for so slow a vessel—her speed in service being only 9 knots.

5. The North Atlantic mail steamer is a very expensive freight carrier, both for the cost of her large crew and for her great first cost. Both these conditions, of course, are consequent upon the nature of her service, her extreme speed of some 13 knots in service necessitating such an immense consumption of fuel, which, with the length of the voyage, increases immensly the size and cost of the ship of comparatively small dead weight capacity. She uses Welsh coal on her voyage out, and American coal coming home, both of which qualities of fuel, of course, are much more expensive than the fuel used in home-trade ships.

The figures given above as the cost of one ton-mile of freight carriage in different lines of steamship traffic, differ very much in amount, and will repay the trouble of some further consideration. The 13 knots North Atlantic mail steamer, having to carry all its coal for a voyage of some 3,000 nautical miles, and being therefore, comparatively to her size and cost, small in dead weight capacity, costs over five times the amount per ton-mile freight of carriage compared with the German Ocean collier doing the same unit of performance.

The principal items of commercial economy of merchant steamers, viz.: cost of coal per ton, speed per ton in service, length of voyage, appear graphically in the diagrams, each of which is intended to illustrate the influence of one of these items upon one of the steamers of our table.

The diagrams are computed in the ordinary manner, and will scarcely need any explanation for being read by the gentlemen present, many of whom have so largely assisted the introduction of the graphical system of investigation.

The object of the writer in compiling the above figures and diagrams was not so much to convey information concerning any novel or extraordinary facts, as an attempt to arrange and reduce to practice, from a commercial point of view, some general items of the present economical conditions under which goods are carried on some principal lines of steamship traffic.

Cold Galvanization of Iron.—The metal is first cleaned by being placed in a bath, made up of water, 1,000 litres; hydrochloric acid, 550 litres; sulphuric acid, 50 litres; glycerine, 20 litres. On being removed from that bath, the metal is placed in a bath containing 10 per cent. of carbonate of potassa, and is next transferred to a metallizing bath, consisting of water, 1,000 litres; chloride of tin, 5 kilogr.; acid sulphate of alumina, 4 kilogr.; chloride of alumina, 10 kilogr. The metal is left in this mixture for from 3 to 12 hours, according to the thickness of the layer of zinc to be desired.

Iron telegraph posts have been introduced with great success in Switzerland, and are now being extended daily. They have been already put up along the railways betwen Basle and Dudingen, Otten and Zurich, and St. Gallen and Rorsehach—a total distance of 350 miles. In Prussia they have been placed experimentally on the railway from Weissenfels to Gera, and on the line between Berlin and Potsdam. As iron is now so cheap, it is considered that in a short time they will altogether replace the old wooden poles in Germany, that cause so frequent interruptions to telegraphic communication from rotting or being blown down by every high wind, especially in exposed situations.

A Telegraph Company is being organized in San Francisco, for the purpose of laying a marine cable to the Sandwich Islands, Japan and China. Congress will be asked for a charter at its next session. It is claimed that this enterprise is favored by the governments of the countries to which it is to be extended.

Minnesota has 950 miles of completed railroads, and 1,130 miles projected and in course of construction.

THE MANUFACTURING INDUSTRY OF SCOTLAND.

From "The Mining Journal."

We propose to lay before our readers a description of the Stobcross Rivet Works, which are about the largest and most complete of their kind in Glasgow, and where the operations carried on bear a close affinity to certain other departments of marine architecture. Although the Stobcross Rivet Works were established in 1840, it was not until some 22 years ago that they passed into the hands of Mr. James Miller, their present proprietor, who had previously superintended their operations as responsible manager. The works were originally built on a much smaller scale, and were altogether more restricted in their operations than at present. Although perfectly compact, the additions made from time to time to meet the exigencies of an extended business impart to the buildings a rather irregular appearance. The main entrance is from Stobcross street, at the western extremity of Glasgow, on the north bank of the Clyde. The buildings appear to form three sides of a square, but there is a large smithy behind, and other accommodation, entirely apart from the premises, which abut upon the front yard. There are 10 lever machines and 1 vertical used for making rivets, but other 2 of the former kind are in process of construction, so that within a short time there will be 13 different machines regularly at work. At present the average production of the works is at the rate of 230 tons of rivets alone per month, and about 200 hands are regularly employed. The rods from which the rivets are made are procured principally from Coatbridge and Workington. The vertical machine is the invention of Mr. Robt. Griffiths, of whom many of our readers will have heard in connection with his improvement of the screw propeller. We believe the vertical is admittedly superior to the lever machine in many respects, and chiefly on account of its increased power of production. It will turn out, on an average, something like 3 tons of rivets per day, or, in other words, about 60 rivets per minute, as compared with 30 rivets per minute from the lever. Hitherto, however, the vertical has been found difficult to manage. Its construction is of a complicated character ; it is readily liable to go wrong, and once out of repair it is not so easy to put it to rights again. For some time past Mr. Miller has been endeavoring to simplify, and render more workable, the arrangements of the vertical, and in this he has been so far successful that when his experiments have been fully carried out he intends to introduce several of the modified machines into his works.

The process of manufacturing rivets is very simple and easy. The rods, which measure from 6 to 12 ft. in length, are first put into a heating-furnace, where they are brought to a welding heat. There are two of these furnaces on the works, and in each furnace there are 2 plates or doors, containing some 10 or 14 holes, just sufficiently large to admit the rods without difficulty. Through these holes the rods are introduced to the furnace, and heated without interfering with the comfort of the man or boy who attends to this part of the business. In other respects the furnaces are similar in appearance and construction to other air-furnaces of the best known kind. As the rods are sufficiently hot for the purposes of manipulation, they are taken in succession from the furnace to the rivet-making machine, where they are cut up into the required lengths by means of a small shears. After passing through this process, the lengths are picked up by another man, who wields a tongs in the one hand, and a hammer in the other. With the tongs the lengths are placed in dies, which correspond with the intended thickness of the rivets, and a good blow from the hammer which the workman wields in his other hand sends them home. There are 10 of these dies or holes for the shaping of the rivets in an ordinary lever machine, and they are placed at regular intervals on a circular iron block or table, which revolves slowly while the process is going on. The dies can be taken from the table at pleasure, and adapted to any size of rivet. In course of revolving, a snap or hammer in the centre of the machine comes down upon and gives shape to the head of the rivet, which is delivered by a tilt at the other side. The rivets usually vary from

$\frac{1}{4}$ to $1\frac{1}{4}$ in. in diameter. So much for the lever machine. The vertical works in a somewhat similar manner, with this important difference, that it is self-feeding, and has 16 dies in the table instead of 10. In the furnaces a large proportion of char is used, and the waste heat is utilized to raise steam in the boilers immediately adjoining. The boilers are two in number, one being attached to each furnace, and are of the well-known Cornish two-flued description. There are two engines on the premises. One is a beam-engine of 45-horse power, 16 in. cylinder, and $3\frac{1}{2}$ ft. stroke. The other is a vertical engine of 14-horse power, 12 in. cylinder, and $2\frac{1}{2}$ ft. stroke. The heavier engine drives all the rivet-making machinery below, and a large fan, made and patented by Russell, of Motherwell, near Glasgow, while the other is used for a number of lathes and other smaller appliances upstairs, as well as to pump water. The whole of the machinery, the engines excepted, has been made on the premises. On the east side of the yards there is a large store used for packing up the rivets in barrels when they are intended for exportation.

In the smiths' shop, which measures about 150 ft. by 40 ft., there are 12 hearths, at each of which 2 men are employed, and it is in this department that the bolts are chiefly manufactured. Russell's improved fan, to which allusion has already been made, supplies the blast for the whole of the fires, and is driven by 2 belts off the large engine. The rods for bolt making are similar to the rivet bolts, but the mode of manipulation and the appliances used are different. After being heated at the smiths' fires—which are, by the way, quite unlike the ordinary hearth, in respect that they are enclosed with brick walls, leaving only a small aperture for introducing the rods and for firing purposes—the rod is cut into short lengths of the size required, not by a self-acting machine, but by the workman himself, and these lengths are in turn put into dies, where they are shaped and headed by a hammer worked by the smith's foot. This machine is called an oliver, and there is one attached to each fire. Nuts are likewise made in the smithy to a considerable extent, but a flat bar of iron is used instead of a rod, and the machine on which they are made is called a fly, the latter being also worked by hand. A separate chimney is attached to each fire, and the shop is ventilated and lighted by large holes in the east and south walls. The fuel used is smithy coal, mixed with char, which gives an admirable fire, and produces very little smoke. Between the smithy and the other departments there is a small yard, in which a well has been sunk to the depth of 120 ft. An ample supply of water is thus continually at hand for the machinery. From this well the water is pumped up into a large iron cistern, which, when full, contains more than sufficient to supply the works for a whole day. An air-pump attached to the smaller engine is adapted to supply the boilers with water from the city mains, the well water containing such a large proportion of lime that its use in the boilers would be highly injurious. Small pipes are led between the principal machines and the large cistern outside, so that the tools are always kept at the requisite point of coolness.

Above the principal rivet shop there is a spacious finishing-room, where a number of women are constantly employed in threading the screws and nuts, and kindred work. The machinery in this department embraces 6 lathes, a planing machine, a vertical machine, and other smaller appliances used in connection with the finishing of bolts, rivets, nuts, and screws. Here, also, the machines used on the works are made, altered, or repaired. The work at which the women are employed, although it may not appear congenial to one's delicate sensibilities, is neither difficult nor harassing, bnt it is very dirty. At one kind of machine they are capping nuts—one of these being capable of capping 4 nuts at a time; at another they are polishing nuts, and at a third they are putting the thread on 2 bolts at a time. There is another machine by which the bolts are pointed instead of being turned. A shaft, from which pulleys and belts communicate with the various machines, runs from end to end of this shop, which is heated by the exhaust steam from the boilers. The drawing or scrap from the bolts and nuts is sold to brokers at the rate of 1s. 1d. per cwt., and after being mixed with other scrap it is sold to the forges, or otherwise disposed of.

Although we have indicated that bolts and nuts are made at these works as well as rivets, the manufacture of the latter is

carried on to a much larger extent than either of the other two. Shipbuilders, bridge-builders, and boiler-makers necessarily use an immense quantity of rivets, and it is from these sources that the rivet works are mainly employed. Some of the shipbuilding firms on the Clyde make their own bolts and rivets, but the majority of them are dependent upon Mr. Miller's and other works of a cognate description, where they can be better and quite as economically supplied.

It only remains to be added that the Stobcross Rivet Works are now so full of orders that operations are carried on day and night, and a further extension of the works is consequently in contemplation.

STARTING-POINT FOR A MODERN STYLE OF ARCHITECTURE.

From "The Building News."

How to bring modern architecture a little nearer to the level of modern wants and circumstances is, of all art questions, the most pressing. In fact, it includes them all. Give us an architecture as fit for our purposes as that of the Middle Ages was for theirs, and all minor problems will soon be solved. But the demand is an immense one. How much it implies, few of those who talk about developing a modern style ever seem to realize. A modern style is not to be invented by one man; it will not start into being in a day or a year. We are not of those who believe, either, that the best chance of obtaining it is to reject the past and begin on the "all original" system. There must be a nucleus around which new ideas can crystallize; there must be a solid foundation on which new additions can be built up. There must be, in short, some style or period of a style assumed as a basis, something in which we can alter what needs alteration, and retain what is worth keeping. The question is, what style affords the most hopeful starting point.

In trying to arrive at a conclusion on this subject, there is at least one circumstance in our favor. We are not left to judge of it merely by logic and *à priori* speculation. There is a far better guide before us—the teaching of experience. With no more trouble than that of walking about the streets of any large town, there are put at our disposal the results of innumerable experiments bearing on this very question. Within the last fifty years it would be hard to say what style has not been tried. Styles and shades of styles without number are being tried at this moment, till it is almost a puzzle to find two architects who employ the same one. Nothing, it is true, shows more fully the unsettled state of modern practice than this. Nothing so clearly measures out to us the distance we have to travel before we attain an architectural system of our own, as the fact that few of us can even agree as to which, of all existing systems, comes the nearest to it. One after another we have tried them all,—Greek, Roman, Italian, and Renaissance; English-Gothic, French-Gothic, Italian-Gothic, Gothic of all periods—Early, Middle, and Late; Romanesque, too, and Byzantine; not to speak of Moorish and Arabian. We have tried them separately, and we have tried them mixed, and after half a century so employed, it is surely not too soon to examine the result. Which has proved most successful in the past; which offers most promise for the future? To attain some general agreement on this question would be an immense step in advance. To pull all together, instead of all pulling in different directions, would soon revolutionize the state of affairs. Even if we could clearly decide what to reject out of all these styles, something would be effected. It would be no slight gain to prevent the extravagant waste of force that is now going on, to settle positively what roads could lead nowhere, and to save every one from wasting his time and trouble on them in future.

To state the objections to many of these styles as a starting-point may seem to most of our readers a needless task. They have practically decided for themselves that Gothic, in one or another of its phases, is alone deserving their attention. But even for those who have most resolutely fixed on their future course, it is not useless to recall the reasons why they have fixed on it. The adoption of Mediæ-

valism because it is the fashion, and its adoption because it comes nearest to what we really want, are two very different things. At the present moment, we have far too much of the former and far too little of the latter. The bulk of modern work could not be so lifeless and unreal as it is, if those who produce it had to account for and defend its characteristics. Its authors are aimlessly drifting with the tide —and should it turn, would drift just as aimlessly in a contrary direction. There is more hope of any class of men than of these. Future art will owe more to those who take up the very worst and absurdest of styles from genuine conviction, than to those who take up the best merely because the popular fancy of the hour may applaud it. The genuine Gothic architect of the day may look with respect on such works as those of Mr. Cockerell or Messrs. Thomson, of Glasgow; he may feel that the designer of the courts at South Kensington was a man and a brother; but what can he think of those who produce the regulation church or schoolhouse of the period? And the public speak of them, too, as Gothic architects; suppose them to be his special friends and colleagues! Of all the dead-alive architecture of the day, he must surely hate dead-alive Gothic the most. That writer might do no slight service who would set in the strongest lights the faults as well as the merits of modern Mediævalism; who, if such a thing were possible, would drive all its followers into following it with intelligence and discrimination; who would force them to decide how far to follow it—what part to keep and what to reject. Such a writer might take a candid survey of other styles, and tell the truth about them. He might insist on the good in them—for there is good in them all—a kind of good, possibly, beyond our reach, or not worth paying the necessary price for—and if so, this truth should also be made clear and unmistakable. But it is truth, and not half truth, that we want; we need not pretend that there is nothing admirable in any style but one, for fear we should desert that one which we have chosen. Those who have taken a course with their eyes open, and made up their minds with full knowledge of the facts, are not so easily to be turned aside. They can bear to recognize the merits of other systems besides their own; for they are either striving to introduce these same merits into their own system, or they see with perfect clearness that it is impossible so to introduce them without destroying greater ones.

A thorough examination, then, of the faults and advantages of the various architectural fashions now in vogue amongst us might lead to useful results. It is too great a subject to be even outlined here, and to many of our readers all its interest would probably be connected with one only of its divisions. They have decided that Gothic is preferable to anything else as a starting-point; but what especial phase of Gothic is best for the purpose is perhaps not equally clear to them. "Early Gothic," we shall probably be told, is the type selected; but Early Gothic may mean two very different things. It may mean, and most frequently, perhaps, does mean, in this connection, a half-developed tracery-system; it may also mean a system in which there is neither tracery nor any necessary tendency towards it. Which of these two is the best foundation for modern work—the incomplete Geometrical, or the perfected Lancet style? The question is no easy one to answer, and the beauty of early tracery windows has commonly decided it in favor of the type which admits them. We are not sure as to the wisdom of this decision. Tracery once allowed, it is not easy to stop its development. Some of our leading architects, having started years ago with its best and earliest forms, have been, and are still, going through a "decline and fall" of Gothic in their own practice. Their plate tracery has grown up into bar tracery—and this into more and more complex forms; the rest of their details have kept it company, and their work has passed on from Early to Middle Gothic, or Later. The breadth and freshness and simplicity which once characterized their work are gone. The hopefulness has vanished from it; the germs of a nineteenth century building style are no longer to be sought there; its authors have given up thinking for themselves, and have swallowed the Mediæval system whole. They "make it" A.D. 1371, and ignore the trifling fact that their clock is five hundred years too slow. It is the natural result of having accepted the principles by which Middle Age art grew old and died. It would surely be safer to

adopt those only by which it first attained perfection; the perfection of the pure Lancet period, which, had it never been exchanged for a puerile and frittered tracery style, might have held its ground against the strongest efforts of the Renaissance. The introduction of tracery was more, perhaps, than anything else, the destruction of Gothic. A pointed style, free from all, even the very slightest, germs of tracery, does not, like an opposite one, plainly contain the seeds of its own ruin. It will, we think, harmonize with a higher class of painting and sculpture, and will not demand an exaggerated quaintness in their productions in order to assimilate them to itself. It is strong, beautiful, and severe—natural and reasonable; fit for an age whose best characteristic is earnest study of facts rather than wild fantastic redundance of imagination.

A REVIEW OF THE TELEGRAPHIC SITUATION.

BY F. L. POPE.

From "The Telegrapher."

The period of time extending from 1864 to 1866 will long be remembered as one of the most exciting periods in American telegraphic history. At the close of the war telegraphic business seemed to increase to an extent before unprecedented. The facilities of the companies then in existence were taxed to the utmost, and rival and competing organizations sprung up in every direction. A sketch of telegraphic history, from that time until the present, may therefore not be entirely destitute of interest and instruction.

In 1864 the principal telegraph companies in the United States were the American, whose lines covered new England and the seaboard and Southern States, and the Western Union, who either owned or controlled all the lines throughout the Western and Northwestern States.

On the 1st of August, 1864, the United States Telegraph Company was organized, by combining several detached and feeble competing lines, and at once proceeded to develop an extensive and vigorous competition with the old companies for the telegraphic business of the country. During the succeeding year this company extended their wires with great rapidity, and secured a large amount of business. The apparent success of the U. S. Company stimulated other enterprises of the kind, and two more competing lines were opened for business on the 2d September, 1865—Bankers and Brokers', from New York to Washington, and the "Insulated," from Boston to Washington. The Franklin Company, between New York and Boston, connecting with the Bankers and Brokers', opened for business on the 16th of January, 1866. The latter company made a fatal mistake in attempting to secure business by cutting the rates 33 per cent., which move was promptly followed by a reduction of 50 per cent. by the U. S. Company, in which all the other companies were necessarily obliged to join.

The United States Company had by this time extended their lines in every direction from New York east to Portland, south to Richmond, and west to Chicago, St. Louis and Omaha, competing with the old companies for the business of the larger cities and towns, with a great degree of success, and were also at work on a line to the Pacific coast. Meantime there were no less than four different companies competing with each other at ruinous tariffs for the business of the best telegraphic territory in the country—that between Boston and Washington.

On the 1st of March, 1866, a most important move was made on the telegraphic chessboard by the consolidation of the United States with the Western Union Company. The causes which led to this result have been pretty thoroughly canvassed, and need not be referred to at length. Extravagant and wasteful management, especially in the earlier stages of the enterprise, and an injudicious distribution of wires—the extent of the system in the West being utterly disproportionate to the limited facilities between Buffalo, Pittsburg and New York—were the principal causes of the failure of the enterprise.

At the time this consolidation took

place, the Western Union Company had 44,000 miles of wire, and the United States Company about 16,000. The absorption of the United States line gave the Western Union control of a large number of lines running through the territory of the American Company, and for a time it seemed that a fight between these two companies was imminent. If the Western Union attempted to operate these lines in competition with the American, the latter proposed to extend their system into the Western States, and thus inaugurate a general war. The only other alternative was another consolidation between the Western Union and American Companies, which was finally arranged and carried into effect July 1, 1861. This gave the Western Union 30,000 more miles of wire, making a total of about 90,000 miles, and its managers considered that their long hoped for monopoly of the telegraph business of the country was at length substantially an accomplished fact.

These various consolidations disposed of all the competing lines, except the Insulated, Franklin, and Bankers and Brokers', between Boston and Washington. Let us glance for a moment at the history and condition of these lines.

The "Insulated" Company was projected with the idea of constructing a line whose wires should be entirely enveloped with some insulating material, thereby enabling them to work well in any state of the weather. This plan for some reason was abandoned, but a well constructed line of four wires was put up between Boston and Washington. No pains or expense were spared to make this a model line, but the style of insulation adopted—probably about the worst that has ever been devised—and the old story of extravagant and inefficient management, together with the reduction of rates before referred to, soon got the company into financial difficulties.

The Bankers and Brokers', at the time of its construction, was probably about the best built line in the country. It had four wires from New York to Philadelphia, and two from Philadelphia to Washington. The enormous profits made by the contractors who built this line, and the debts in which it entirely became involved, from lack of proper business management, involved it in pecuniary embarrassment, from which subsequent good administration failed to extricate it.

The Franklin line of two wires from New York to Boston, at an early period of its history, passed under the control of practical telegraph men, who secured the property at a reasonable cost and worked it with a good degree of success. This company secured the control of the Insulated lines on the 1st of May, 1867; but the debts of the latter company, and the wretched condition of its wires, arising from bad insulation, have proved a heavy load for the former company to carry.

Up to the latter part of 1866 no serious competition to the Western Union Company had developed itself, other than the lines above referred to between Boston and Washington, but efforts were being made in various other parts of the country to organize another system of competing lines. The first fruits of this movement appeared in the opening of a new line, under the name of the Pacific and Atlantic, between Baltimore and Pittsburg, which took place on the 10th of December, 1866. This enterprise was in the hands of a number of prominent Pittsburg men, who soon began to show that they meant business. Reaching Philadelphia and New York by means of the Insulated wires from Baltimore, they soon extended their wires into the oil regions, and also towards the West. In 1867, two wires were built over the Pennsylvania Railroad from Pittsburg to Philadelphia. On the 1st of May, 1868, this company had 1,853 miles of line and 3,244 miles of wire. In October, 1868, they purchased the lines of the Southern Telegraph Company, extending from Cincinnati to Nashville, Louisville and Memphis, which were built in 1867. In October, 1869, they purchased the lines of the Mississippi Valley Telegraph Company, extending from Chicago to Dubuque, St. Paul and St. Louis, embracing about 2,500 miles of wire, which had been built during the years 1867 and 1868. In the following month their lines reached Chicago, and within a few days afterwards opened between Philadelphia and New York. Since that time this company have been engaged in adding to their facilities on existing routes, and in extending their southwestern lines towards New Orleans.

The Atlantic and Pacific Company

originated in New York, and was organized in 1866. Active operations were commenced early in 1867, and on the 15th of October of that year the line was opened for business between New York and Buffalo, and Cleveland was placed in connection on the 8th of January following. From various causes the work went on rather slowly the following year, and it was not until November 3d, 1868, that the Chicago office was opened for business. The Great Western Company, working in connection with them, had already reached Milwaukee, and was subsequently extended to Omaha. Branches were built by the Atlantic and Pacific Company to Detroit and Cincinnati, and other minor points, as their work progressed. In June, 1870, an arrangement was made placing the control of the Pacific Railroad wires in the hands of this company, and on the 10th of that month communication was established with the Pacific coast.

In the meantime a number of tributary lines, of more or less importance, had been constructed to work in connection with the lines already mentioned. The Dominion Company of Canada commenced operations in 1868, and in connection with the People's Company have constructed quite an extensive range of lines in the Dominion, connecting with the A. and P. Company at Suspension Bridge. The International line from Boston to Bath, Me., was opened Jan. 26, 1867, and has since been extended to Bangor.

Name of Company.	Miles of Poles.	Miles of Wire.	Number of Offices.	Number of Operators.
Atlantic and Pacific......	3,744	8,313	238	352
Pacific and Atlantic......	4,155	8,280	167	300
Franklin....	800	2,780	76	100
Bankers and Brokers'....	284	1,095	37	43
International..........	412	743	51	59
Philadelphia, Reading and Pottsville............	505	926	115	180
Great Western	1,500	800	49	54
Southern and Atlantic....	370	752	10	10
Dominion..............	629	1,116	35	40
People's	250	500	20	24
Delaware River..........	248	248	25	25
Northern	130	130	12	12
Total............	14,033	25,683	830	1,200

The Northern Telegraph Company started from Boston with the intention of reaching Montreal, but stopped at Bristol, N. H., to which place it was opened in September, 1867.

The extent and importance of the competing lines in the United States at the commencement of the present year may be seen from the preceding table, which was compiled from official sources. A number of lines of small importance and extent, which exchange business with the competing lines, are not included in the table, and amount, probably, to two or three thousand miles of wire in addition.

The Southern and Atlantic Company have only commenced operations at a comparatively recent date; they are building from Washington to New Orleans—which point they will probably reach during the present year.

It will be seen that the competing lines, including the various minor lines connecting with them, comprise nearly twice as many miles of wire as the United States Company did at the time of its consolidation with the Western Union. A consolidation of these various lines into one organization would enable it to compete very successfully with its powerful rival. Its facilities would be far greater than those of the United States Company, not merely on account of having more wires, but of a better class, and distributed in much better accordance with the requirements of the business. It would have 6 wires from New York to Boston, 15 between New York and Philadelphia, 8 between Philadelphia and Washington, 3 from New York to Buffalo, and 4 from New York to Pittsburg. Thus the important routes are very well provided for.

The true policy of these competing companies is the consolidation of interests into one compact and powerful organization, which shall be able to compete successfully with their great rival for the telegraph business of the country. This course has been persistently advocated in the columns of "The Telegrapher," as the only one which can enable them to secure pecuniary advantages, and permanently maintain the competition which the public imperatively demand, and for which so much capital has already been invested.

This brief sketch of telegraphic history demonstrates the futility of the efforts of any combination, however powerful, to maintain a monopoly of the telegraph business in this country. The people, by repeated investments, in spite of the fact

of continued loss and sacrifice, have shown that they will not submit to a telegraphic monopoly. Only in the hands of the Government, and by Congressional enactment, as in the case of postal communication, can such a monopoly be sustained. The prospects of the establishment of a Government Telegraph System are not very bright, at least for some years to come, and in the meantime the facts here collated are commended to the serious consideration of all interested parties.

ON THE STRENGTH OF PORTLAND CEMENT.

From "The Builder."

At the Institution of Civil Engineers, on April 25th, Mr. Vignoles, F. R. S., president, in the chair, the paper read was on "Further Experiments on the Strength of Portland Cement," by Mr. John Grant, M. Inst. C. E.

In a previous paper the author had stated* that "further experiments were desirable, on the strength of and adhesion between bricks and cement under varying circumstances ; on the limit to the increase of strength with age ; on the relative strength of concrete made with various proportions of cement and ballast," etc. The experiments described in this paper were made with the view of throwing additional light upon these points, and might serve to show those interested in the subject the direction which their inquiries might advantageously take, and the large field yet open for their labors.

Before describing the new series of experiments, some of the points in the previous paper were reviewed.

The next step was to establish the conditions to be observed in the following new series of experiments:

A. On the strength of Portland cement tested by tensile strain at different periods, from 1 day to 12 months, mixed by hand and ground in a mortar-mill.

B. On the adhesion between bricks cemented with Portland cement and lime mortars, tested by tensile strain at the end of 12 months.

C. On the strength of Portland cement neat, and with different proportions of sand, tested at the end of 12 months, by compression in a hydraulic press. Size, 9 in. by $4\frac{1}{2}$ in. by 3 in.

D. On concretes of different proportions of Portland cement and lime, with gravel, sand, and other materials, tested at the end of 12 months by compression. Size 12 in. by 12 in. by 12 in., and 6. in. by 6 in. by 6 in.

For these experiments 38 bushels of Portland cement were procured; the gross weight being 4,300 lbs. 11 oz., or 113.176 lbs. per bushel. When sifted through a sieve of 400 holes per sq. in., this was reduced to 4,201 lbs. 4 oz., or 110.56 lbs. per "striked" bushel. About 36 lbs. were afterwards rubbed through the sieve ; 34 lbs. would not pass, and there was a loss of 29 lbs. A certain quantity of cement was sifted, when it was found that the gain by sifting was about 14 per cent.

The following were the weights per bushel and per cubic ft. of the materials used in the new series of experiments :

Materials.	Weight of 1 bushel. lb.	Weight of 1 cubic ft. lb.
Portland cement	110.56	86.375
Sand and ballast	123.40	96.400
Portland stone	98.00	76.560
Broken granite	116.00	90.625
" pottery	113.00	88 280
" slag	107.00	83.594
" flints	126.00	98 440
" glass	120.00	93.750

Table VI., Series A, gave the strength of the Portland cement used throughout these experiments at different periods from 1 day to 12 months; first, mixed by hand, and next, mixed in a mortar-mill for 30 min. In the first case the maximum strength seemed to have been attained at 4 months; in the second, at 1 month; the greatest strength of that mixed by hand was about double that mixed in a mortar-mill. The hand-mixed cement maintained its strength; the mill-mixed declined from its maximum at a month to the end of the experiments. This result was probably due partly to the process of crystallization, or setting, having been interrupted by the continued agitation, and partly to the destruction by

* *Vide* Minutes of Proceedings Inst. C. E., Session 1865–6, vol. xxv., p. 66.

attrition of the angular form of the particles.

Table VII., Series B, on the tensile strain required to separate bricks cemented together with Portland cement and lime mortars, would require to be greatly extended before trustworthy deductions could be made from them. In the case of perforated bricks, the cement mortar seemed to act as dowels between the bricks, and the results were consequently high. The Suffolk and Fareham red bricks adhered well to the mortar.

Table VIII., Series C, on the strength of Portland cement bricks tested by crushing, was, so far as it went, very instructive. As a rule, strength increased with density. When the cement was in less proportions to the sand than 1 to 2, or 1 to 3, those dried in air bore a greater pressure than those kept for 12 months in water. This would lead to the inference, that when the quantity of cement was small, bricks or blocks of concrete should be kept some time out of water, to harden before being used. Contrasting the strength of these concrete bricks with different clay bricks, it was found that down to the proportion of 6 to 1 the former compared favorably. Thus, bricks made of neat cement bore a pressure equal to that of Staffordshire blue bricks or best Fareham red bricks. Bricks made in the proportions of from 2 to 1 to 6 to 1 of cement were equal to picked clay bricks of 6 varieties.

The D series showed the strength of concrete bricks made with Portland cement, mixed with various materials in different proportions, and crushed after being kept a year, half of them in air and half in water. The general deductions were, that those made with the largest proportion of cement were the strongest, the strength being nearly in proportion to the quantity of cement. Tables were given of the strength of 12 in. and 6 in. cubes of concrete made with ballast, Portland stone, broken granite, pottery, slag, flints, and glass, mixed with Portland cement in the proportions of 6, 8, and 10 to 1, and compressed. Half was kept in water for 12 months. The most prominent result of these tables was that concrete made of broken stone or broken pottery, was much stronger than that made of gravel; due, no doubt, partly to the greater proportion of cement absorbed in the latter case in cementing the finer particles of sand, and partly to the want of angularity in the gravel. Compression and an increase in the proportion of cement alike increased strength. In making concrete bricks or blocks of moderate size, compression might be applied with advantage; but with large masses of concrete it would be difficult to do so without running the risk of interrupting the process of crystallization or setting, which commenced immediately on the application of moisture. The cost of labor so applied would therefore be better employed in a larger admixture of cement.

The different modes of using Portland cement in the construction of sewers were described ; in some cases only as a foundation or as a backing for brickwork; in others sewers, 4 ft. 6 in. by 3 ft., of concrete were lined with half-brickwork; and in other instances sewers were formed entirely of concrete, in the proportions of 1 of cement to 6 of sand. The cost of this concrete was less than half that of brickwork; but if rendered inside with cement, it was about the same as if lined with half-brick—perhaps the cheapest form of sewer, combining strength with soundness. Sewers and culverts of almost any size might be made on this principle. Sewers made of concrete, and not rendered inside, though somewhat cheaper, had one practical disadvantage in busy thoroughfares, inasmuch as they required a long length of centring, on account of the slow setting of the concrete, and it was, therefore, necessary that about double the length of trench should be open at one time. The cost of a concrete sewer, 4 ft. by 2 ft. 8 in., was 10s. per lineal foot, exclusive of excavation. Under the same contract, a brick sewer, of the same size, 9 in. thick, cost 16s. 6d. Another concrete sewer, 7 ft. 1 in. in diameter, cost 16s., or, inclusive of earthwork, side-entrances, junctions, etc., about 23s. per lineal foot. This sewer was, in some respects, exceptional, inasmuch as it consisted of little more than an arch over a previously-existing invert. The lower half was, however, rendered with cement and sand, in equal proportions, 1 in. thick. Everything being taken into consideration, the most economical combination was $4\frac{1}{2}$ in. of brickwork in cement, and the rest in concrete. Another sewer, 9 ft. by 9 ft., of concrete,

with a lining of 4½-in. brick in cement, was mentioned.

In the construction of the Albert, or Southern Thames Embankment, it was originally intended to form the wall of brickwork, with a granite facing; but after about a fourth part of the work had been executed, 14,335 cubic yards of Portland cement concrete, made in the proportions of 6 to 1, at 11s. per cubic yard, were substituted for an equal quantity of brickwork, at 30s. per cubic yard.

From the experience already gained in the use of Portland cement concrete, there would seem to be hardly any limit to the purposes to which it might be applied. It was gradually being brought into use in the construction of dwelling-houses in different parts of the country, and there was no doubt it would be still more extensively employed in the construction of docks, piers, breakwaters, and other massive engineering works.

Many experiments had been made in the manufacture of bricks of different proportions of Portland cement and sand, and these were equal in strength and appearance to most kinds of clay brick. Where concrete could be used in a mass, it was cheaper than when used in the form of blocks, and still cheaper than in the form of bricks. In 1867, a number of arches were formed with "Bétons Agglomérés," by M. Coignet, under the steps leading from Westminster Bridge to the Albert Embankment; also about 40 ft. of sewer, 4 ft. by 2 ft. by 8 in., in the Camberwell Road. Similar arches and sewers were constructed of Portland cement concrete, and the general result was that the Portland cement concrete was both stronger and cheaper than the béton.

Tables were given of the strength of 589,271 bushels of Portland cement used during the last 5 years on various works south of the Thames, showing an average tensile strain at the end of a week of 806.63 lbs., equal to 358.5 lbs. per sq. in., being an improvement on that reported 5 years ago of 200 lbs. on the breaking area of 2¼ sq. in., or 89 lbs. per sq. in. The quality had not only been maintained, but had continued to improve. The strength at the end of 30 days of 37,200 bushels of the same cement, as ascertained by 1,180 tests, averaged 1,024 lbs., equal to 455 lbs. per sq. in., showing an average of 234 lbs., or 30 per cent. over the cement tested at 7 days, which broke at 790 lbs. Wherever the nature of the work would admit of it, tests at the end of a month would be found more satisfactory than if made earlier, as heavy cements, though the strongest eventually, were the slowest to set. The standard originally specified was 400 lbs. on 2¼ sq. in.,and this was soon afterwards raised to 500 lbs., or 222 lbs. per sq. in. This had since been increased to 350 lbs. per sq. in., or 787 lbs. on the breaking area at 7 days. For the purpose of comparison the same sectional area at the breaking point (2.25 sq. in.) had been retained. Further experience had confirmed the earlier conclusions, that the strength of Portland cement increased with its specific gravity, its more perfect pulverization, and its thorough admixture with the minimum quantity of water in forming mortar. Heavy cement, weighing 123 lbs. a bushel, like that referred to in Table XVIII., took about two years to attain its maximum strength used neat; but by the admixture of sand or gravel, cement, mortar, or concrete was reduced in strength, and set less rapidly than neat cement. Roman cement, though from its quick setting property very valuable for many purposes, deteriorated by exposure to the air before use, and was about double the cost of Portland cement, if measured by strength. In making cement concrete, it would from this seem desirable to spend no more than was absolutely necessary to effect a thorough admixture of the cement with the sand and gravel.

Upwards of eighty messages were despatched from and received at Madras on the first two days after the opening of the Madras and Penang telegraph line. The Indian Government is about to erect an additional wire between Madras and Bombay, in anticipation of the utilization for business of the cables to China and Australia.

The Hongkong-Shanghai Telegraph Cable.—The Great Northern Telegraph, China and Japan Extension Company have received information that the laying of the Hongkong-Shanghai cable was successfully completed on the 29th of March, and that the cable is in perfect condition.

THE MINERAL RESOURCES OF CHINA.

From "The Mining Journal."

Although comparatively little is known in this country concerning mines and mining in the Chinese Empire, it seems certain that they are not altogether neglected. Of the mineral wealth of Szechuen, and the western provinces, only a mere sketch can be given. The commonest product under this head is coal, which is found in abundance everywhere, from below Pa-tung-hien to Chungking. It is worked by a cheap and easy process on the hill sides, is sold at the pit's mouth in some places at as low as 30 cash per picul (say 2½d. per cwt.), and is very generally consumed both for domestic and manufacturing purposes in all parts of the country. Around Chungking itself the coal mines are particularly productive, and constitute a rather important item in the industry of the neighborhood. The best quality of coal is said to be that found near Khwei. The only complaint the natives have to make against it is that it burns too fast ; hence they economize by pounding it small and mixing with earth, so forming a kind of patent fuel, which they call *tan-yuen.*

The metal trade is not regarded as of very great importance in Szechuen, but metals generally are under Government monopoly, or are permitted to be worked under Government license. Gold bars are brought from Kweichow and Yunnan, and are also made out of the gold dust found in the bed of the Kinshakciang or Golden Sand river, by which name the Upper Yang-tsze is sometimes known, and which is no mere fanciful appellation. The waters of the river are undoubtedly charged with gold, which is annually deposited among the pebbles in its bed. On the subsidence of the summer flood the natives commence washing for gold, beginning at a short distance below Wan, and extending to the upper part of the river.

The occupation is not very remunerative—the workmen have little left after paying the license to the authorities; and in case they did improve their fortunes by a successful search, there is little doubt that the taxes would be increased. Silver comes from Yunnan and Kweichow. Copper and white copper (petung) are found in the province of Yunnan and Kweichow, and are taken for sale to Jinhwaiting. Whitecopper also comes from Hwuylichow, in Ningyuanfoo, in Southern Szechuen. Only a small quantity of Chinese red copper comes to market at Hankow. Spelter (peyuen) comes from the same quarter and is also collected at Jinhwaiting. It is used to mix with copper, to manufacture, cash, and is at present reported to be sent in large quantities to Japan. Tin (seih) is found in Yunnan, also in Hoonan and Kweichow. The produce of Yunnan and Hoonan is collected at Yuenchowfoo, the other at Jinhwaiting. There are several qualities, the best being called tienseih. Lead (hihyuen) is said to come from Tungchuenfoo, in Yunnan. Quicksilver is found in Kweichow; sulphur in small quantities there also, and in various parts of Szechuen. Iron is very abundant and very cheap in Szechuen. Chingyuchang, in Chingtoo prefecture, is mentioned as a place where it is produced in large quantities; in Yunnan it is also abundant, and used locally.

The province of Kweichow is, perhaps, the least known of the eighteen into which China is divided. It has suffered severely by a war with the mandarins, cholera, and other epidemics, so that one town, for example, of 50,000 inhabitants was reduced to 200 families, of which but six belonged originally to the place, the remainder being immigrants from Szechuen. The aggregate result has been to reduce the population from 6,000,000 to less than 1,000,000. The Catholic bishop resident at Kweiyang, the capital, who passed down the Yangtsze last May, described the country between his residence and the borders of Szechuen as a depopulated jungle, and the trees as having been everywhere cut down by the ill-paid soldiery for fuel. Kweichow, though less fertile than many other provinces of China, has still elements of prosperity in its available resources. It is rich in mines of lead and copper, but especially of quicksilver, which latter were being worked to great advantage previously to the late rebellions, but have not been since resumed.

The province of Hupeh contains, as far at least as is known, but little coal; but it

is always necessary to remember that what the Chinese call bad coal, and not worth working, may after all overlie some really valuable deposits. Nowhere in Hupeh are there any largely worked or important mines. At some hills, not far from Anluifu, on the Han river, a poor earth coal is found and used in the coarse pottery works in that city, but is not exported elsewhere. At Ichangfu, on the borders of Szechuen, a rather better coal is found, and exported to places in the immediate neighborhood. In the neighboring province of Hunan large and valuable fields of bituminous coal exist, and have long been worked. The district is traversed from north-east to south-west by the Hsiang river, the principal feeder of the Tungtinghu. It is mountainous, and intersected by small streams, whose waters are subject to all the vicissitudes incidental to mountainous districts, and the continual, sudden, and very violent rains peculiar to Hunan do not diminish the dangers from floods either to the mines or the boatmen conveying the coal down to the depot at Hsientanhsien. The coal field lies in the jurisdiction of the three prefectures of Yungchowfu, Henchowfu, and Paochingfu, and may be roughly estimated as extending about 30 miles from north to south, and about 33 from east to west. Near Paochingfu a non-bituminous coal, called iron coal, is found, and is extensively used in potteries, and for smelting iron; it is exported in considerable quantities, and in the distilleries, felt factories, and forges at Hankow and elsewhere. The chief mines for this coal are stated to be at Nieumassu and Chiangshuiwan, about 30 li from the prefectural city.

With regard to the mines themselves, they are driven horizontally into the sides of the hills, and often penetrate them to a considerable depth. These shafts, or rather passages, are of no great size, and average about 4 ft. wide by 6 ft. high, and necessitate the miners working in a stooping posture; their roofs are propped up at intervals by wooden supports, and the rotting or breaking of these is a fruitful cause of accident, men being often crushed to death by the displacement of portions of the roof. Still more dangerous are the floods and heavy rains which are frequent in Hunan, and many miners are annually destroyed by the sudden flooding of the mines, or by the destruction wrought in the roofs and sides of the passages by the damp and wet. Fire-damp, however, so fatal in English mines, seems unknown, or nearly so, to the Chinese more simple methods of excavation, though it is stated it occasionally appears, but never in very large quantities. Agreeably to Chinese customs the system of co-operation seems generally prevalent, and each mine is the property of one or more families, who contribute the men and the material for working it, afterwards dividing the profits among themselves. As the hills are the property of the State, large proprietors are unable to monopolize these sources of national wealth, and no rent troubles these humble mine owners beyound the land tax universally due to the Emperor from the eighteen provinces.

In addition to the great coal field above treated of, there remain two other small districts, one in the extreme south of Hunan, in the magistracy of Hsintienhsien, whose produce is said to be considerable, and of value, but which is all sent southwards into the adjacent provinces of Kuangtung and Kuang-hsi; no very accurate, reliable, or detailed information can, therefore, be obtained about it in Hankow. The other is in the magistracy of Loong-shan-hsien, in the prefecture of Yung-shun-fu, in the north-west corner of Hunan, bordering on Szechuen. This coal field is reported to be extensive, and was worked as far back as the times of the Ming dynasty, but it is now said to be exhausted, and a little, but very inferior, coal is obtained from it. It is, however, by no means impossible that foreign skill might discover fresh deposits deeper down in the earth, and render once more valuable these now nearly useless mines, as it is likewise certain that acquaintance with the foreign methods of mining would render still more productive the great central coal field of Hunan, and the possible more universal introduction of steamers for the navigation of the inland waters of China will soon render necessary what is now a mere matter of speculation—namely, that the practically unlimited resources of fuel in Hunan should be opened up and rendered fully accessible to foreign skill, energy, and capital. With how great advantage to the people of China, it is needless to state. No accurate statistics

are obtainable of the amount of coal annually brought down from Hunan. The foreign steamboat companies consume nearly 16,000 tons per annum, and the extent of country depending for supplies of fuel on Hunan must be very large. The valley of the Yang-tsze is probably the principal market, and the vast population dwelling on its banks appears to depend for its fuel chiefly on Hunan.

Returning to Szechuen, it should be mentioned that salt is another important source of its wealth. It is produced in many parts of the province, as in Foochow and in the prefecture of Khwei, but the largest supplies are found in Wotungkeaou, in Keatingfoo, where *hihpa*, a white kind, is made from springs; in Sz'lewkin, in Fooshunhien, where another white kind, called Sz'yen, is made; and in Shayhunghien, in Tungchuenfoo, whence it comes in black and white blocks, some white, and some very dirty. A license is necessary to enable a merchant to deal in salt, which is said to cost 20,000 taels, besides paying which the applicant is supposed to find security for his possession of sufficient capital to carry on the trade. The license remains in the family, transmissible from one generation to another, but each successive holder is required to pay 10,000 taels to the mandarins, besides making them frequent presents. So the matter was described to us, but in point of fact the cost of a salt license probably depends on the terms which the holder of it can succeed in making with the mandarins.

The salt trade of Szechuen received a very important stimulus from the closing of the navigation of the lower Yang-tsze, in consequence of the capture of Nanking, and the occupation of the river by the Taepings. Up to that time the whole of the provinces of Hoopeh, Hoonan, Kiangsi, and Anwhuy, had been supplied with the "Hwai-yen" salt, so called from its passing Hwai-kwan barrier, to its depot at Yang-chow, all other salt being contraband. But when communication with Yang-chow had been stopped, the Viceroy Taou petitioned the Emperor to permit the Szechuen salt to be brought for sale to Hankow, which was, of course, granted, and Szechuen salt kept possession of the market until the opening of the river navigation by foreigners in 1861. The "Hwai-yen" salt again began to come to Hankaow in 1862; and for some years past Tseng-kwo-fan has been making great exertions to bring the trade back to its old channel, petitioning to have the Szechuen salt again interdicted in Hoopeh.

Time will be required, however, before the trade can be organized on its former footing, for the old monopolists, or Yenshang, were dispersed by the rebellion, and the mandarins have been obliged to grant licenses to new men of inferior standing, called Yen-fan. The authorities are, however, making every effort to place the matter on a permanent basis, compelling applicants for license to go to Peking, and making the license not transferable. The Hwai-yen salt arriving in Hankow is placed under the control of an officer, called "Tuh-seao Hwai-yen-keuh," who regulates the price at which it shall be sold, and the order in which the boats shall discharge, the owner having no voice in the matter. With Szechuen salt it is different, for having paid duty at Ichang on the way down, it is henceforth free from official interference.

The North German Lloyds.—This great undertaking has now 3 steamers running on a Bremen and Aspinwall line. The line comprises 3 new iron screw steamers of 3,000 tons burthen each, and named respectively the King William I., the Crown Prince Frederick William, and the Count Bismarck. These vessels were built on the Clyde, and they have direct-acting engines of 300-horse power nominal. The run between Bremen and Aspinwall is to be made in 18 days. After discharging at Aspinwall, the steamers will proceed to Laguayra, touching at Savanilla and Puerto Cabello.

It is expected that the broken section of cable between the Islands of Shapinsay and Eday, on the Shetland circuit of the Orkney and Shetland Islands telegraph, will be repaired about the first week in May. Owing to the rapid tideway and strong currents, from the exposed position of the Stransay Frith to the North Atlantic Ocean, the operation attending the repair will be one of great difficulty and danger.

ON STEEL AS APPLIED TO SHIP BUILDING.

By J. B. HOWELL, Esq.

From the "Journal of the Society of Arts."

In the year 1853, I called the attention of shipbuilders and engineers generally to the value of mild cast-steel as a material especially adapted for shipbuilding and kindred purposes, and for a long time I failed to make any valuable impression upon those I thought most likely to entertain the subject. I was not merely unsuccessful, but I found, in many instances, a positive aversion to the use of steel for constructive purposes. This aversion, I have no doubt, was caused by the habitual thought of public opinion respecting steel being synonymous with brittleness. Finding this objection so constantly occurring, it suggested to my mind the necessity of giving it another name, and after about two years of fruitless effort, I introduced it as "Howell's Homogeneous Metal." This was the origin of the successful application of steel for boilers, tubes, ships, and locomotive fire-boxes. Messrs. Laird, of Birkenhead, constructed the little vessel called the "Ma Robert," for the Livingstone expedition. This is the first instance of the application of steel for shipbuilding; but since that time, mild cast-steel has been used very extensively for this and other purposes, where strength and lightness is a first consideration. We are now enabled to make steel suitable in the highest degree for shipbuilding, and I beg to call your attention to the samples exhibited. All these samples have been bent cold, which is a simple and safe test for steel plates; and some of them, before bending, have been heated to a red heat and plunged into cold water, which is a doubly sure test; these particular pieces are marked "A," but they do not appear to have suffered from the severe ordeal they have passed through. The samples are bent to show the angles to which the various thicknesses of plates should be bent, as a proof of their suitability for ship plates. The extreme test of 180 deg. is beyond the necessary test for plates of this character, but plates up to $\frac{1}{4}$ in. in thickness should always bear bending to that degree. The steel may be easily sheared, punched, caulked, and welded, and is 50 per cent. more rigid than iron. The term steel can barely be applied to this metal, as the very small amount of carbon it contains would prevent its being put in the same category as steel. The samples on the table contain 0.2 per cent. of carbon. This, I consider, should be the maximum quantity of carbon in steel intended for shipbuilding; for all plates containing this quantity of carbon never fail to give the required tests practically. We have discovered, in our long and extensive experience, certain irons as being the most suitable for the manufacture of these plates, and as there is no reasonable limit to the supply of these irons, there is no difficulty in turning out large quantities of these plates regular in their manufacture. The strength in tension of this steel is about 36 tons per sq. in., and the limit of elasticity about 23 tons. From this it can be seen that the rigidity of mild cast-steel is nearly two-thirds of its ultimate breaking strain. The limit of elasticity in iron is only one half of the breaking strain. Steel is, beyond doubt, stronger than iron; it is much stiffer and far more ductile; and, I think, were it used only for the skeleton of ships plated with iron, it would be a great gain in strength and stiffness of the whole structure.

Steel plates of 1 in. and less in thickness will resist the impact of shot much better than iron. During the experiments at Shoeburyness, conducted by the Iron Plate Committee, and referred to by Sir William Fairbairn in the "Transactions" of the tenth session of this institution, steel plates $\frac{1}{4}$ in. thick were found to have a resistance equal to iron plates $\frac{1}{2}$ in. thick, and steel plates $\frac{3}{4}$ in. thick were equal to iron 1 in. thick, and steel plates 1 in. thick had a resistance exceeding iron plates $1\frac{1}{4}$ in. thick, but not equalling iron plates $1\frac{1}{2}$ in. thick. The steel plates $2\frac{1}{2}$ in. and 3 in. thick had no value against the impact of shot, and the first shot in each instance shattered the plates. This result we were quite prepared to expect, as our mechanical appliances were not equal to the successful manufacture of large, thick plates. To insure ductility in mild steel plates we require a blow or

squeeze sufficiently great to change the granular structure of the cast metal, so that, when broken by tension, it has a conchoidal fracture, or, as it is understood in the trade, knock fibre into it. The market price of these plates, also angles and bars, is from £25 to £30 per ton—a price, I think, sufficiently low to create a demand for them; for although it may seem a large price compared with ordinary ship-plate iron, it will be found economical to use it, not only in the durability of the ship and in repairs, but in the greater safety to life and cargo.

Many persons who have used steel for constructive purposes have even now a great objection to it. This has entirely arisen from inferior and irregular manufacture, due as much to the consumer as the maker, for the cupidity of both has in many instances induced the adoption of a low-priced article, which has failed to give satisfaction. Had manufacturers been careful to see that plates had what I consider the requisite characteristics for constructive purposes, and which are not difficult to determine, I believe the steel of to-day would not only be the future of iron, as Mr. Scott Russell has said on a former occasion, but had the proper precaution been taken in selecting the proper material, the steel of the past would have been the present of iron. It is desirable, where convenient, that the drill should be used instead of the punch in perforating the rivet holes in all steel plates; and I would further advise that, as soon as possible after their manufacture, they should be well payed, and, where convenient, submerged in boiling linseed oil. I have found in my experience that plates thus coated, after three years' exposure to the weather, have not shown the slightest tendency to corrosion, though subjected to alternate wet and dry. I consider the life of the plates will be lengthened greatly by this process, and the plates will take the paint much better after it. It is most important that destructive oxidation should be avoided as much as possible. The newly-formed oxide arising from the heat of the furnace does not decay until exposed. The oxide formed on steel plates in the fire is much more tenacious than that formed on iron, and forms more completely part of the plate, being difficult to remove without exposure or abrasion.

I have carefully avoided drawing comparisons between different qualities and makes of steel, but have confined myself to a steel which I consider the most suitable for shipbuilding, taking into consideration the most suitable material, and keeping within the price that I conceive may be paid to make it commercially profitable. Where great strength is required, irrespective of cost, then I should recommend steel, such as the armor plates referred to earlier in my paper, the breaking strain of which, under tension, is 46 tons to the sq. in. I would on no account, as far as my experience enables me to judge, use a steel of higher tensile strength than this, as every ton gained in strength beyond this limit is at the cost of ductility, which is important in all structures that are liable to sudden concussion; not but that you can get steel of higher tension with great ductility, but 40 tons is within the limit of certainty. The limit of elasticity of this steel is 30 tons per sq. in. This quality of plates is extensively used for locomotive fire-boxes, a great number of which are now in use on the Scottish Central Railway, giving the fullest satisfaction; some, indeed, have been working upwards of 9 years. The market price of these plates is £40 per ton, a price which has always prevented shipbuilders from entertaining the idea of using them for shipbuilding.

THE Japanese have abandoned the old method of printing from wood-cuts alone, as learned from China, and are establishing type founderies, electrotyping, and stereotyping establishments. They are being instructed by Europeans and Americans, and large orders for material have been received in the United States. With the Roman type will come the use of our language.

THE following figures serve to show the magnitude of railway traffic in England and Scotland: On sixteen of the leading lines of road there are 7,925 locomotives, 17,636 passenger cars, 135,990 freight cars, 8,575 cattle cars, and 73,750 coal cars.

THE tower on the Brooklyn side of the East River bridge is going up rapidly.

ON THE CONDITION OF CARBON AND SILICON IN IRON AND STEEL.

From "The Journal of Iron and Steel Institute."

No one can examine the statements contained in metallurgical works, regarding the condition of carbon and silicon in iron and steel, without being struck with their vagueness, and the unsatisfactory state of our knowledge of this important subject. That these elements do exist, in some form or other, and that they exercise an all-powerful influence upon the nature of the metallic compound, is admitted by all; while in the case of carbon, at least, it is now generally allowed that it may exist, either diffused through the mass, as graphite, or be present in some form of combination with the iron. But there are no proofs that this diffused graphite, or "kish," as the workmen term it, when it occurs on the surface, is pure carbon, nor any very satisfactory data as to the nature of the combination of iron and carbon; and it is only necessary to state a few of the theories on the latter point, to show that we require more workers in this field of research, to clear up the mist in which the subject is at present shrouded. As a small contribution in this direction, the following results are submitted to the members of the Iron and Steel Institute.

Thus, while Berthier believed he had discovered a simple compound of 1 atom of iron with 1 of carbon, that is in the proportion by weight of 28 parts of the former with 6 of the latter, Berzelius believed in the existence of a compound of 2 atoms of carbon with 1 of iron, and also of 1 with 3 atoms of carbon to 2 of iron; Karsten and Ramelsberg hold to a compound of 4 atoms of the metal with one of the non-metal; Gurlt advocates the existence of a further compound of 8 of iron to 1 of carbon; and lastly, Von Mayrhofer thinks that definite substances of the formulæ Fe_4C, Fe_5C, Fe_8C, $Fe_{10}C$, and $Fe_{12}C$, may be present under different conditions.

With respect to graphitic carbon, our able metallurgist, Dr. Percy, in his justly celebrated work on iron and steel (p. 128), has the following statement, which, so far as the author knows, has not hitherto been contradicted. Speaking of the separation of graphite from pig iron, he says: "The fact of graphitic carbon being left by the solvent action of acids is certain evidence that this carbon was not present in the solidified metal, at least in a certain degree, in chemical combination with the iron. With regard to any distinct flakes of graphite which may be separated, there can be no reasonable doubt, though according to my experience, even they retain iron in some form or other, which is difficult to dissolve out completely. Moreover, when we carefully inspect the fractured surface of a piece of even highly graphitic iron, every part presents more or less of a graphitic lustre, yet not a trace of graphite can be detached by the point of a pen-knife."

It was this latter statement which led to the following investigation, the details of which, the author thought, could not be placed before a more fitting audience than the members of the Iron and Steel Institute. The methods of analysis followed, in order to elucidate the condition of carbon and silicon, have opened a fresh field of research, which will be alluded to in its place, and which it is hoped may lead to further and more important results.

But if the practical bearing of the investigation be not at present apparent, the author hopes his contribution may not be unacceptable to the members of the Iron and Steel Institute, as he believes the day has gone by for practice alone to reign supreme, and that rapid progress in manufacturing industry is only to be obtained when theory and practice go hand in hand.

There is no subject requiring more study than the chemistry of iron and steel, for every step in their manufacture involves a chemical problem, and the author cannot let the present opportunity pass without suggesting the desirability of this institution affording substantial aid in the matter, by the establishment of a laboratory for research. The British Association are doing something; but what is now suggested is the appointment of a chemist who should be in communication with the great body of scientific ironmasters throughout the country, and

be able to verify results, not by mere laboratory experiments, but by actual trials on a manufacturing scale.

The incorrectness of the statements respecting the separation of graphite from crystals of iron, became evident from the examination of some largely crystallized pig iron, which, having run over the tymp, had cooled slowly in a tub of slag. It was noticed that, in this case, the graphite could be separated from the faces of the crystals, not merely by the point of a penknife, but even by the finger-nail; and that having once detached the scale of graphite, the surface beneath was metallic iron. On exposure to a damp atmosphere, it was found that the metal became rusted below the scales of graphite, which then fell off. Continuing the observation, it was found that the same separation of graphite could be obtained from the faces of the crystals of Bessemer pig, and that the smallest crystal of gray iron was coated with its layer of graphite, which by appropriate means could be easily removed.

This being the case, it was at once seen, that by carefully removing these graphitic scales, we ought to be able to settle the question whether they were pure carbon, or a compound of carbon with iron, silicon, etc. It need scarcely be stated that the separation of a sufficient quantity of these scales for an analysis, is a tedious occupation, and that even with the greatest care it is almost impossible to prevent fine particles of iron, dust, etc., from contaminating them. By a little trouble, however, .0345 grammes of these scales were removed from the facets of crystals of compact gray iron. These were burnt in a stream of oxygen, when there was left a residue weighing only .0015 grammes, consisting mainly of a few microscopic particles of sand with the merest trace of red oxide of iron, resulting no doubt from the oxidation of the foreign particles of metal with which the graphite was contaminated. The carbonic acid found weighed .104 grammes, which is equivalent to .0283 grammes pure carbon; so that, even if the incombustible residue had been all peroxide of iron, there must at least have been 126 atoms of carbon to 1 of iron.

As the graphite could be thus easily removed from the crystals of pig iron, it was thought that other mechanical processes might be applied for its separation, and that the magnetic property of iron might also be made available. Some graphitic pig was therefore pounded in a steel mortar, to coarse particles, which, by their attrition, rubbed off the scales of graphite from the crystalline facets. The iron was removed by a magnet, and the graphite left behind. But here it was still more difficult to remove the last traces of metal; .1045 grammes of the graphite, after combustion, left a residue weighing .012 grammes, consisting of .008 oxide of iron, and .004 sand, silica, etc. As the Fe_2O_3 would be formed from .0056 grammes iron, and .0024 grammes oxygen absorbed, this latter weight must be added to the loss by combustion, thus making the total graphite burnt .0949 grammes. The carbonic acid found weighed .3505 grammes = .0955 grammes pure carbon, so that even here there was 17 times as much carbon as iron, or 46 atoms metal to one of the non-metal.

Lastly, .1415 grammes of kish, purified with hydrochloric and hydrofluoric acids, gave .518 grammes carbonic acid, equal to .14154 grammes pure carbon, and left no residue that could be weighed.

These results, we think, are sufficient to prove that scales of graphite can be removed from compact gray iron, and that these scales consist of pure carbon, for it is morally certain that the traces of iron found with them were simply accidental, and in no way combined with the carbon.

Graphite being much more friable than metallic iron, it was believed that it would be reduced to finer powder than the metal, in the process of drilling. Some gray Bessemer pig was therefore reduced to borings, and these were sifted through a very fine silk sieve. The original pig, coarse part, and fine portion which passed through the sieve, were analyzed separately, with the following results:

Total Carbon per cent. in 3 Trials on different Pigs.

	Original Pig.	Coarse part of Borings.	Fine part which passed through the Sieve.
(1.)	3.008	2.559	7.605
(2.)	3.331	—	9.214
(3.)	4.071	—	9.288

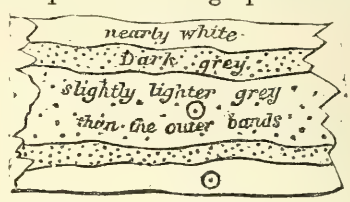
Again, graphite being so much lighter than iron, recourse was had to specific gravity as a means of separation. Two makes of iron were employed, viz.:—a

Middlesbrough gray forge pig, and ordinary Bessemer pig. The borings from each were divided into two portions, one half being sifted as above, and the other part separated by agitating with distilled water, and pouring off the lighter portions for analysis. These several products were completely analyzed, with the results recorded at the end of the paper. The carbon per cent. found in each case was :

	Original Pig.		Fine part separated by sieve.	Light part separated by specific. gravity.
(1.) Bessemer Pig	Graphite	3.341	9.11	28.48 per cent.
	Combined Carbon	—	—	
(2.) " "	Graphite	3.190	7.79	21.274 "
	Combined Carbon	.2	.17	
(3.) Middlesbrough Forge Pig	Graphite	2.650	7.015	41.329 "
	Combined Carbon	.35	.30	

These results show clearly that in gray pig iron the carbon exists in two states, and that the free, or graphitic carbon can be more or less separated by mechanical means, while the so called "combined carbon" decreases in the separated portions in the same ratio as the residual iron.

In spiegeleisen, refined metal, white pig, steel, and wrought iron, almost the whole of the carbon exists in combination, very little graphite being present ; but the amount of graphite, as is well known, depends to some extent upon the rate of cooling of the fluid iron. Thus, if even gray Bessemer pig be cast in chill moulds the outer portions will be white and "case hardened," and, as a proof that there is less graphite in this than in the central gray part, the following analyses of a piece of bad forge pig may be cited. It will be seen that the white portion contains .25 per cent. less graphite than the



gray, although the total carbon was the same in each case. The piece of iron had the above appearance on fracture, and was drilled for analysis at the points marked ⊙

			Composition of White part.		Composition of Gray part.
Iron			92.240		92.150
Carbon	Graphite	.850	2.573	Graphite 1.100	2.584
	Combined	1.723		Combined 1.484	
Silicon	1st estimation	3.978	3.972	1st estimation 4.001	3.989
	2d "	3.966		2d " 3.978	
Sulphur			.355		.375
Phosphorus			.702		.731
Manganese			.216		.234
Other Metals			Absent		Absent
			100.058		100.063

The largest amounts of graphitic carbon are contained in gray Bessemer pig ; and of combined carbon in spiegeleisen, this alloy of iron and manganese having the property of retaining carbon in "combination" to a greater extent than iron alone. Some old analyses have been published, in which the total carbon in different classes of iron is shown as high as 6 per cent.; but in some hundreds of analyses of all brands of iron that have been made by the author, he has never, in a single case, found the carbon to reach 5 per cent., and this he thinks will be corroborated by all who have made analyses with our modern improved means of research.

From the experiments of our Vice-President, Mr. I. L. Bell, it would appear that some of this carbon is taken up by the ore during the process of reduction; but it is commonly supposed that the greater portion is taken up after complete reduction, and that the great cause leading to high carbon in pig iron is long contact of the fused metal at a high temperature in contact with carbon. The nature of the slag has an important effect in determining the quantity of carbon, which appears to reach its maximum when the

blast is hottest, slag most basic, ores least silicious, and burden light.

Whether there is any definite chemical compound of carbon and iron, or, as Dr. Percy suggests, of carbon, iron, and manganese, there is, we think, no data to decide; but judging from the few experiments which have been made, we are inclined to believe that the absorption of carbon by iron is a case of that weak kind of chemical action termed solution, and that there is no definite chemical compound of the two elements. It appears more probable that iron dissolves carbon *per se*, and retains it more or less on solidifying, according to the quantity that has to be taken up, the proportion of manganese present, the rapidity with which cooling is effected, and the amounts of such other bodies as silicon, sulphur, phosphorus, etc., held by the iron. It is generally the case that solution of a solid takes place more freely the higher the temperature, and so it appears to be with iron and carbon. That the carbon retained in the iron from mere solution should so marvellously affect its nature, according to the quantity present, is no greater wonder than that the diffusion of a small quantity of a definite chemical compound, of any one of the formulæ proposed should do; and altogether it seems more simple, and in accordance with fact, to suppose that carbon is held in solution and not in chemical combination in the ordinary sense of the term. The properties of any other solvent are more or less altered by dissolving various substances in it. Water, for instance, dissolves varying quantities of common salt according to the temperature, and although it will take up a certain weight without altering its bulk, yet the specific gravity is increased, freezing point lowered, and in many respects it is different from pure water. Again, after it has been saturated with salt, it is still capable of dissolving other bodies, as, for instance, alum. No one, however, regards the union of water, salt, and alum, in this case, as a definite chemical compound. Why, then, should not the union of carbon with iron be regarded as a similar case of solution? The fact that the union remains on solidification has its parallel in the case of mercury, which dissolves tin, in varying proportions, and the union remains on solidification.

Silicon.—This element is invariably contained in pig iron, and the author has never yet met with a case of even steel or wrought iron, in which it was entirely absent, though in good Bessemer and tool steel it rarely exceeds 2 or 3 parts in 10,000 of iron. When present in Bessemer steel, to the extent of about $\frac{1}{10}$th per cent., or 1 part in 1,000, it has the effect of rendering the steel hard and brittle when cold. Its presence in iron is due to the reduction of silica, which takes place in the blast furnace; and the conditions favoring its passage into iron are high temperature, light burden, free silica in the charge, and deficiency of lime, alumina, and other bases in the slag. It is also sometimes stated that the quantity of silicon passing into the iron will depend upon the pressure of the blast, but this evidently resolves itself into a question of temperature, as the greater the pressure, within certain limits, the more intense will be the combustion.

In ordinary Bessemer pig, silicon occurs in quantities varying from 1 to 4 per cent.; while white pig iron may contain mere traces, and spiegeleisen seldom has more than a few tenths per cent. It gives considerable trouble to the puddler in removal, and occasions great loss of yield in the process. Hence the desirability of having forge pig as free as possible from silicon. In the Bessemer process, on the other hand, it serves a very useful purpose, as during the blow it is burnt or oxidized, with the evolution of much heat. But, as in puddling, it occasions considerable loss of iron, and provided a sufficient temperature can be obtained, the less silicon there is in the pig the better. As, however, carbon is never present in sufficient quantity to generate all the heat required in the process, it is only when the iron contains large amounts of manganese, that silicon can be dispensed with below about 2 per cent. In some Swedish and Styrian Bessemer pigs, containing about 3 per cent. manganese, the silicon is under 1 per cent., and yet the charge works very hot. When iron or steel is dissolved in mineral acids, the silicon is oxidized, and silica separates along with the graphite, in a gelatinous state; hence it is generally believed to have been in chemical combination with the iron. It is, however, an element similar in many respects to carbon. Thus carbon is known to exist

in at least 3 different states, viz.: crystallized as the diamond, in semi-crystalline condition as graphite, and in an amorphous state as charcoal, lampblack, etc. Silicon has also been obtained in a pulverulent or amorphous form, in a graphitic state, and in the adamantine (or diamond) crystallized condition. One would then naturally expect that it would be found in iron in the same state as carbon, and, indeed, this is the generally received opinion; but a careful examination of the proofs of its existence in the graphitoidal or free state, failed to satisfy the author that this was the case.

As silicon, like graphite, is non-magnetic, and of low specific gravity (2.49), it appeared to the author that if it existed in the free state, the methods which succeeded in separating graphite should also answer for the separation of silicon.

The following analyses, some of which are of very silicious pig, show that silicon cannot be separated in this way.

Amount of Silicon per cent. in

	1 Original Pig.	2 Coarse part.	3 Fine part separated by sieving.	4 Light portions separated by spec. gravity.
West Cumberland Bessemer Pig	2.419	2.477	2.380	
Dowlais Bessemer Pig	3 77	—	3.433	2.93
" "	3.849	—	3.639	3.158
Middlesbrough Pig	1.815	—	1.610	1.219

Thus we see that instead of the silicon increasing in the finer and lighter portions, as the graphite did, the reverse is the case. It actually decreases, and in the same proportion as the carbon increases; in fact it remains with the metallic iron just as the "combined" carbon does, so that the coarse part, after removing some graphite, contains an increased proportion of iron and silicon, while the finer portion contains a less per cent. of these elements. It appears, then, that it must have been in combination or solution in the iron, and that it is, at least, an exceptional case, if it is found in the free state.

It may be well here to allude to those cases in which silicon has been stated to have occurred free. The most important instance is that of Richter, of Leoben, who asserted that he had found silicon in defined crystals in pig iron; but the editors of "Kerl's Metallurgy" suggest that this "may have been a compound of silicon and iron, as a small amount of iron was found in it." Percy states that the late M. Henry believed he had discovered crystallized silicon among the scales of graphite from pig iron, and that he himself regarded the evolution of gas like hydrogen, which took place on putting some graphitic scales (obtained from one of the Dowlais furnaces as "kish") into molten potash, as most probably caused by the presence of free silicon.

The balance of evidence, then, appears to favor the theory that silicon is dissolved or (to borrow a word which perhaps more nearly expresses the state of combination) "occluded" in the iron in the same way as the carbon, but that the solvent power of the metal is so much greater for silicon than for carbon, that it is quite a rare thing even if it ever occurs, for silicon to separate in a free state from the iron.

This greater solvent power for silicon is fully proved by the fact that carbon never exists to a much greater extent than 5 per cent., whereas Scotch pig iron has been found with as much as 8 per cent. silicon, and Dr. Percy succeeded in obtaining a melted metallic product with 18.77 per cent. silicon by reducing sulphide of iron in contact with sand and charcoal; indeed it seems to be an easy matter to obtain a compound of iron with 10, 12, or 15 per cent. silicon. The author has not yet had an opportunity of applying the methods of mechanical separation to such products as these, but hopes to do so before long. It is generally supposed that the absorption of much silicon tends to set free carbon in the graphitic state. Pig iron containing much silicon melts readily, and is generally weak and easily broken; and, indeed, from long observation, the author can generally tell whether the Bessemer pig contains high or low silicon, by the facility with which the workmen break the pigs by dropping them on the △ iron.

No direct experiments have been made on the tensile strength of pig iron containing a constancy of other elements with varying quantities of silicon, but Fairbairn and others have ascertained the strength of particular brands of pig iron after several successive meltings, and have found that the metal generally increases in strength up to a certain point, and then each fusion reduces the resistance to rupture. Now, the author believes the explanation of this to be, that at each successive melting, the silicon, and perhaps to a slight extent, the carbon, decreases; but the iron gradually takes up sulphur and phosphorus from the fuel, and the deterioration due to these elements more than counterbalances the increased strength due to diminished silicon and carbon. This theory seems to be borne out by the specific gravity of the samples, which shows a gradual increase throughout.

According to Price and Nicholson, Calvert and Johnson, and Lan, nearly the whole of the silicon is removed in the process of puddling before the carbon is touched, but it by no means follows that, because it is easily oxidized, it has no injurious effect in delaying the process; indeed the author has very positive evidence that the reverse is the case.

In the Welsh refinery process, and also in the Heaton process of conversion, the same rapid removal of silicon takes place, as is seen in the following analysis:

		White Pig Iron.		Refined Metal made from former.
Iron		94.006		96.485
Carbon	Graphite .8 Combined 1.797	2.597		2.428
Silicon	1.918 1.899	1.908	.126 .130	.128
Sulphur		.553		.144
Phosphorus		.886		.815
Manganese		.050		Trace.
		100.000		100.000

Conversion by Nitrate of Soda Process.

		Mix Pig used. A.		B.	Samples of crude converter metal made from preceding. Hard piece.	Soft piece.
Iron	(Direct)	93.997	(By diff.)	94.030	(Direct) 97.435	(By diff.) 98.486
Carbon	2.36 graph. .446 com.	2.806		2.570	(All com.) 2.061	1.098
Silicon	2 011 2.002	2.006	1.946 1.973	1.959	.014	Trace
Sulphur		.034		Trace	Trace	Trace
Phosphorus		.446		.558	.489	.344
Manganese		.648		.885	.064	.072
		99.937		100 000	100.063	100.000

It was formerly supposed that in the Bessemer process the whole of the silicon was removed before the carbon was touched; but, as was stated by Mr. C. P. Sandberg (in a paper communicated by him to the Institute of Civil Engineers), from experiments by the author of this paper, it has been found that this is not the case. These two elements are both rapidly oxidized from the commencement of the blow, but the silicon being more easily attacked, disappears quickest. If, however, the pig iron contains an excess of silicon, and but little carbon, this latter may be all burnt out, and the body of flame disappear, so that the workmen may suppose the metal to be fully blown, while it still contains sufficient silicon to render the steel very brittle. This is, of course, a very exceptional circumstance, and can never take place if the "charge" is properly regulated; but that it does sometimes occur is fully proved from the following analyses of underblown steel, which, it is right to state, are the only instances of the kind that have come under the author's observation during the course of his extended experience at the Dowlais Works. He has been informed, however, by other metallurgists, that they have occasionally met with similar instances. An analysis of "Iron

Skull," from a Bessemer reverberatory melting furnace, exhibits the same phenomenon.

Lest it should be supposed that the brittleness of the steel here mentioned, is in any way due to the presence of other elements, the analysis of ordinary Dowlais steel rails is given, which, it is well known, are seldom broken by the fall of the ton-monkey from a height of 20 to 30 ft.

Underblown Steel, containing High Silicon.

No. 1.	Carbon	.445
	Silicon	.814
No. 2.	Carbon	.515
	Silicon	.270

Iron Skull from Melting Furnace.

Iron	98.348
Carbon	.729
Silicon	.665
Sulphur	.110
Phosphorus	Trace
Manganese	Trace
	99.852

	Brittle Steel, with High Silicon.	Good Steel.
Iron	98.120	98.831
Carbon	.550	.490
Silicon	{.634, .644, .644} .640	.009
Sulphur	{.069, .066} .067	.033
Phosphorus	.038	.036
Manganese	.554	.576
Copper	.031	.025
	100.000	100.000

The gradual oxidation of carbon along with the silicon from the commencement, is shown by the following analyses of metal taken during the blow. These statements regarding the removal of carbon and retention of silicon have been corroborated by Professor Tunner, and also by a Swedish matallurgist of repute.

Analyses of Bessemer Metal during the "Blow" of the Pig used, and Steel Produced.

	Melted Charge of Pig.	No. 1. Sample taken at the end of first stage, 6 min. from start.	No. 2. Taken 9 min. from start.	No. 3. Taken at finish before adding spiegel. 13 min. from start.	Steel Borings from an ingot.	Steel Borings from rail crop ends.
Iron	94.682	97.245				
Carbon	{Graph. 2.07, Com. 1.20} *a* 3.218	*b* 2.17	1.55	.097	.566	.519
Silicon	{1.964, 1.941} 1.952	{.792, .798} .795	{.635, .635} .635	.020	.030	.033
Sulphur	.014	Trace	Trace	Trace	Trace	Trace
Phosphorus	{.050, .047} .048	{.055, .048} .051	.064	.067	.055	.053
Manganese	.086	Trace	Trace	Trace	.309	.309
Copper	—	—	—	—	.039	.039

Wrought iron is frequently to be met with, which is not at all brittle, and yet contains enough silicon to have produced decided cold shortness in steel. The author believes that this apparent inertness of silicon is in part at least due to the fact that in any product like steel which has been molten, the whole of the silicon present must be in the combined or "occluded" condition, while in the case of wrought iron which has been in a pasty state, much of the silicon shown in analyses really occurs as silica in the interposed slag, which does not materially affect the strength of the metal, but renders its wearing properties vastly inferior to those of steel. The author has recently met with a sample of iron, containing a large percentage of this interposed slag, and found the composition in this case to be:

Silicon	.155	in 1.069 slag.
Phosphorus	.189	
Iron	.231	

which, if calculated to the states in which these bodies probably existed, would be:

Silica	.333	=	31.25 per cent.
Phosphoric acid	.433	=	40.505 " "
Protoxide of iron	.297	=	27.843 " "

It is this interposed slag which renders

a The total carbon is estimated by direct combustion, the graphite and combined by separate experiments.
b All combined.

built up or "piled" rails so liable to be crushed, as it prevents perfect union or welding of the crystals of iron.

In like manner very fair wrought iron contains amounts of sulphur and phosphorus that would be fatal to steel, and the same explanation may probably be applied here.

There does appear, however, to be some difference in the modes of existence of sulphur and phosphorus in pig iron, for in completing the analyses of the various products obtained by mechanical separation as explained above, the author was struck with the remarkable and unexpected fact, that the finer portions which contained most graphite, contained also an increased per cent. sulphur, while the phosphorus decreased in about the same ratio as the iron. The manganese also appears to accompany the sulphur to some extent.

It might possibly be thought that this difference arose from errors of analysis, but it is too great to be thus accounted for even with the most careless manipulation, while the author need scarcely state that every possible precaution to guard against error has been taken, and not only have almost all the experiments been made in duplicate, often in triplicate, and when possible by two different methods, but the re-agents were carefully tested for purity, and the precipitates proved to be pure and what they professed to be.

This part of the subject requires further investigation, and the author hopes at some future time to communicate the results of additional experiments. There is no doubt that the methods of mechanical separation adopted by the author for the investigation of the condition of carbon and the silicon, will prove effectual aids to the ultimate analysis of iron, and a valuable supplement to ordinary methods of research.

Complete Analyses of Samples of Pig Iron, after Mechanical Separation of their Constituents.

MIDDLESBROUGH GRAY FORGE PIG.

	A Original Pig Iron.	B Fine part, which passed through silk sieve, about No. 130.	C Light portions, separated by specific gravity (by washing).	D Lightest portions separated by specific gravity (by wash).
Iron	....	....	57.735	54.733
Carbon............	Graphite {2.69 direct; 2.61 ×HF} Combined .35 } 3 000	Graphite {7.05; 6.98} Combined .3 } 7.315	Graphite 37.623	Graphite 41.044
Silicon............	1.81, 1.82 } 1.815	1.60, 1.62 } 1.610	1.240	1.211
Sulphur...........	068 by Aq. Regia; .073 by H Cl.& K ClO_3 } .070	.205, .173 } .189	.760	.644
Phosphorus........	1.79, 1.77 } 1.780	1.81, 1.74 } 1.770	1.345	1.344
Manganese........	.504, .490 } .497	.482	1.383	.875
Calcium	Absent	Absent	Absent	Absent

DOWLAIS BESSEMER PIG—SIMILARLY TREATED.

	A	B	C	D
Iron................	....	....	86.101	75.278
Carbon	Graphite {3 04; 2.94} Combined .2 } 3.19	Graphite {7 64; 7.60} Combined .17 } 7.790	Graphite 10.111	Graphite 21.274
Silicon	.3826, .3873 } ...3.849	3.658, 3 261 } 3.639	3.443	3.131, 3.185 } 3.158
Sulphur...........	.011	.035, .038 } .036	.054	.068, .065 } .066
Phosphorus........	.081, .076 } ... .078	.072, .069 } .070	.070	.058, .058 } .058
Manganese..........	.244	.230	.216	.164

Coarse part of Borings remaining after the separation of C and D.

MIDDLESBROUGH PIG.

Iron	94.200
Graphite	1 884
Silicon	1.885
Sulphur	.060
Phosphorus	1.773
Manganese	.490

DOWLAIS BESSEMER PIG.

Iron	93.708
Graphite	2.072
Silicon	3.880
Sulphur	.011
Phosphorus	.079
Manganese	.240

It should be mentioned that of 712.8 grammes of fine borings of the Middlesbrough pig, 68.8 grammes or 9.65 per cent. passed through the sieve and formed the part marked B in analysis, while of 2,551 grammes of Dowlais pig 194 were passed through the sieve. In the case of the light portions separated from the remaining halves of the borings by specific gravity, only a very small proportion of the whole was obtained which was not estimated.

In concluding this paper, the author begs to record his appreciation of the efficient services rendered in the above investigation by his assistant, Mr. W. Jenkins.

At the close of the reading, the following remarks were offered in reply:

Mr. I. Lowthian Bell: The able and highly interesting paper just read requires for its proper appreciation some previous consideration, and hence we must all admit how useful it will be for members who may have anything to communicate to the Institute to comply with the recommendation of the Council, and allow their respective papers to be printed and circulated previous to the day of meeting.

I entirely agree in Mr. Snelus's dissent from the conclusion arrived at by Dr. Percy, in respect to the separation of graphite from the faces of crystals in pig iron; for I do not remember ever having failed in being able to detect this substance in the manner named by the reader of the paper.

I was glad to notice the applause which followed Mr. Snelus's remarks on the propriety of establishing a chemical laboratory in connection with the Institute; not because I am very sanguine of its practicability in our own case, but because I see in your approbation a recognition of the importance you attach to chemical science in connection with your profession as iron manufacturers.

I would just observe, in allusion to what occurs in the paper we have just heard, respecting my own labors in connection with carbon deposition in iron ore during the process of smelting, that I considered I had proved the dissociation of carbonic oxide is effected at a temperture much lower than that at which it has been hitherto supposed to take place, and that complete reduction of the oxide of iron is by no means essential for its occurrence. I do not, however, pretend to say that there is any combination of the iron and the carbon at this low temperature, which probably does not happen until the hearth of the furnace is reached. I would remark, in reference to Mr. Snelus's supposition that silicon is perhaps dissolved or "occluded" in larger quantities by iron than is carbon, that I have observed that silicon is certainly found occasionally in pig iron more abundantly than even happens with carbon; but I do not agree with him that it never separates from the iron something in the manner of carbon. I have, upon more occasions than one, found the exterior of the "pigs," and in particular cavities in the sows or runners, coated with fibrous silica of such a physical aspect as to permit no other explanation than that it arose from silicon extracted from the iron in cooling, and oxidized as it came in contact with the atmosphere.

Of the retarding effect of silicon in puddling, I have had frequent experience. I recollect receiving a parcel of glazed or silvery pig, rich in silicon, which resisted all attempts either of refining or puddling, and was only got rid of by using infinitesimally small quantities with other iron.

Mr. Bessemer: I wish to make a few remarks as to the presence of silicon in steel. A very general opinion prevails in the trade (and it is a correct opinion when we speak of large quantities) that silicon is very injurious to the quality of iron, and that by getting entirely rid of it you make iron of a superior quality. This, however, is not the case with cast steel. In proof of which I call attention to the old steel process, as carried on at Sheffield, where the highest qualities of iron are used—some of the brands of Swedish

iron show not a trace of silicon. When iron of this high quality is put into the crucible, and melted with a sufficient quantity of carbon to produce steel, one would suppose, from the absence of silicon, that we should have the finest quality of steel. But it is not so, when heat sufficient only for fusion is used; for if the ingot be then poured it will not work soundly under the hammer. The old trade term for steel in this condition is, "not well melted," signifying that it has not been long enough in the furnace, although fusion is complete. In order to ascertain the cause of this defect in steel, I have made the following experiment: I have taken Danamora iron, and cut up the bar into small pieces, and put them in equal quantities into two separate crucibles, and placed them side by side in the same furnace. The heat and all other conditions were precisely the same. When complete fusion had taken place, one of the crucibles was drawn and the ingot cast. The second crucible was left in the furnace for two hours longer, and the heat considerably increased. The second crucible was then poured out; the result was that the first ingot went to pieces under the hammer, and in the second instance it worked admirably, more like a piece of copper than steel. It would thus appear that the continued heat had taken out something from the metal, or had been the cause of some additions thereto, for it could not be the iron, which was the same in both cases; but analysis proves the fact that there was silicon in the second ingot and not in the first. The carbon in the crucible had converted the wrought iron into steel, and had also reduced some of the silica, always present in the form of sand at the bottom of the pit; and to that accidental circumstance the Sheffield manufacturer owes the production of his best steel. In making the crucible, it is difficult to get the core into its proper place, and it has been found necessary to make a hole in the bottom of it for that purpose; and when the crucible is placed in the furnace a handful of sand is thrown into it to stop the aperture. This use of sand has really been the unknown secret of making the best quality of steel; for if you keep the steel in the furnace at a high temperature, enough silica is always reduced by the carbon, and in the metallic form is alloyed with the iron. I offer this fact as a proof that the presence of silica (which is so injurious in large quantities) is necessary in small quantities in steel. Indeed, I have not had a single analysis of the best quality of Sheffield steel that did not contain silicon.

The noble President: Before we dismiss Mr. Snelus's paper, he wishes to make some remarks in reply.

Mr. Snelus: I wish to make one or two remarks as to what Mr. Bell has said with regard to the deposition of carbon in ore during the process of reduction. I have made a few experiments in that direction, and I think the deposition of carbon in ore, during the process of reduction, is due to the action of the fine particles upon the gas at high temperatures. For this reason, I took pure sand—although in this case I used coal gas, and the conditions were slightly different from those of Mr. Bell—but I took fine angular pieces of sand, and heated them in the tube, through which I passed coal gas, and on the angular particles carbon was deposited, while none was deposited on the smooth surface of the porcelain tube. So that I think the deposition of carbon in ore at a low temperature is due to other causes than the chemical action of the reduced iron. I find, as Mr. Bell stated, that reduced ore generally contains more or less carbonaceous matter, but it is not in a state of chemical combination. You are probably acquainted with the color test of Eggertz, for combined carbon. Now, I have taken iron ore, which I had perfectly reduced at low temperature, and on dissolving it in nitric acid, as in the Eggertz method, no color was obtained, but a residue of free carbon was left, showing that this carbon was not in chemical combination with the iron. I have not a word to say as to Mr. Bessemer's remarks, except that in my experience I have never known an instance, as stated in the paper, in which the very finest qualities of iron or steel were perfectly free from silicon. There is an example of Mr. Bessemer's own steel, which contains 0.009 per cent.; in fact, so small is the quantity that we were scarcely able to estimate it, but we did estimate it, and there is the actual quantity. And I have never found a case in which, on dissolving iron or steel in large quantities, you did not

see silica in solution floating about, proving that the iron contained silicon. With regard to the separation of free silica from iron, the instance given by Mr. Bell shows that that was an exceptional circumstance, and I am not sure that it was separated from the pig iron as silicon ; or whether the form in which Mr. Bell found it as free silica, was not due to other causes. It is well known that free silica is found in blast furnaces frequently, and that has been pointed to as a proof that silicon existed in pig iron in a free state. But I do not see the connection, because I think silica may be found in a free state in blast furnaces without ever having entered into the composition of pig iron.

HYDRAULIC TRAIN LIFTS.

From "Engineering."

The terminal points of the railways from Aix-la-Chapelle to Homberg, and from Oberhausen to Ruhort, are situated on the right and left branches of the Rhine, by which river they are separated. So early as 1847 propositions were made for the construction of works to join the two lines, and in 1852, by the joint efforts of the executives of the railways, a steam ferry was established, with satisfactory results. The junctions between the ferry boats and the stations had been made in the ordinary way, with inclined planes of 1 in 10, and the shunting of the carriages and wagons between the boats and the stations was done by shunting engines, which, however, did not travel on the inclined planes, but moved the trains by means of wire ropes. This system, however, was found to possess considerable disadvantages, and after various plans had been tried, with more or less success, it was finally determined to abandon the inclined plane altogether, and substitute for it between the boats and the station level the hydraulic lift.

The ferry boat, a side-wheel steamer of 200 horse-power, with two oscillating cylinders of 46.4 in. in diameter, and 37 in. stroke, was built by Messrs. Jacobi & Co., of Sterkrade; it has a flat deck 171 ft. 6 in. long, and 26 ft. 9 in. wide amidships. It carries 3 parallel lines of rails, which give accommodation for about 20 10-ton goods wagons. The depth of the boat is about 9 ft., the draught of water when empty is 36 in., and when loaded 48 in. Steering apparatus is provided at both ends, and the diameter of the paddle wheels is 14 ft. 5 in.

The lifts are placed on each side of the river, and the platform for lowering or raising the wagons, moves vertically in the tower as shown. This platform is framed upon iron girders, and carries 3 lines of rail, corresponding to those on the ferry boat. The pairs of rails at the sides are 24 ft. 8 in. long, but the central pair is extended in the direction of the station to a length of 36 ft. These latter are employed for the long 6-wheeled trucks, and the former for the shorter 4-wheeled trucks. The platform moves in the lower part of the tower upon girders bolted to timber beams built into the brickwork. Of course the height of lift varies according to the level of the water; the platform can be lowered to the lowest level of the water, whilst its highest position is fixed by projecting beams. The longest stroke or lift of the platform is 27 ft. 6 in., but the height most commonly required varies between 13 ft. and 16 ft. The lower part of the lift tower is open on the side towards the water, and the ferry boat enters this opening, being kept in position by guide and fender piles, and being protected from injury by suitable buffers.

When the platform is fully lowered it rests upon the end of the boat, to which it is connected by means of a coupling apparatus, and the trucks are then shifted from the boat to the platform, on which they are lifted to the station level.

The platform is lifted by means of hydraulic presses, which are placed in the upper part of the tower. The main lifting cylinder is 29.84 ft. in length, with metal 2 in. thick. This is placed in the centre of the building on wrought-iron cross girders, about 19 ft. above the station level. A plunger, 29.84 ft. long and 12 in. in diameter, works within the cylinder, and to the upper end of the piston is secured a cross-

head to which are attached, first, the guide blocks, which work against rails which are supported within the tower by timber framings; second, the 2 chains carrying the platform; third, 2 chains which are taken up to the top of the tower, and, passing over pulleys, support counterpoises weighing 25 tons collectively. These are employed to balance the dead weight of the piston and the platform. Fourth, a chain which passes over rollers, and is connected at its other end with a second and smaller lifting cylinder, 7.48 in. in diameter, and with a stroke equal to half that of the main cylinder. The chain before spoken of is not attached direct to the piston, but passes over a pulley upon it, and is then connected to the cylinder in such a way, that not only half the pressure, but the full stroke of the piston is transferred to the chains. The small cylinder is generally employed only for lifting the empty platform; but both cylinders may be employed together in case any unusually heavy load has to be lifted.

The pumps supplying the water are not placed in the tower, but in a separate engine-house at the side of the station. This engine-house contains a horizontal high-pressure engine of 30-horse power, with 2 cylinders of 13.77 in. diameter. The piston-rods of these cylinders drive direct the double-acting pumps for the hydraulic presses in the lifting tower. The water, however, is not pumped direct into the water tower, but passes into an accumulator, provided with a plunger piston, from which is suspended a counterpoise consisting of an iron box filled with kentledge. The piston is 19.68 ft. long and 16.53 in. in diameter, and it exerts a pressure upon the water of 57.6 tons, or 650 lbs. per sq. in. The effective cubic contents of the accumulator is equal to the sum of the cubic contents of the 2 cylinders in the water tower. The loaded box of the accumulator piston is provided with brackets and chains, by which the safety valve is opened, and the throttle of the steam pipe closed, so soon as the piston has reversed its highest position. The engine then works very slowly without producing any further lift of the loaded box, but employs again its full power as soon as a portion of the water in the accumulator has been consumed. Additional pumps are provided for pumping from the well into a tank and for feeding the boilers. The pressure main passes through the lower part of the tower into a receiver with valves, from which the water is distributed as required. The receiver is made of cast iron, and consists of tubular chambers, from which the water is carried off by 4 pipes, namely: 1st, the pressure main; 2d, the waste pipe leading to a small reservoir under the roof of the tower, and thence into the main reservoir of the engine-house; 3d, the pipe to the main cylinder; and 4th, the pipe to the small cylinder. Each of these pipes is provided with separate valves, by means of which the required combinations are effected. There is in addition a self-acting safety-valve within the tank, which opens into the pressure main as soon as the downward motion of the platform produces in the lifting cylinder a greater pressure than exists in the main itself. Another valve, serving a similar purpose, is also placed between the distributing chamber and the main cylinder. Two other self-acting valves are also added for the purpose of filling the one cylinder with water not under pressure, while the other cylinder only is acting, so that empty spaces or vacuums are prevented.

The cost of constructing the ferry was £19,850, of which £7,011 were expended on the machinery, and £11,865 for the boat. After the work had been erected, and sufficient experience had been obtained as to its satisfactory working, a second boat was constructed and put to work. This boat, which cost £11,227, gives accommodation for 16 10-ton wagons, and is fitted with engines of 400-horse power.

The average work done by the ferry with 1 boat is 16 wagons per hour; the time for crossing the Rhine varies from 10 to 15 min., according to the level of the water; the lifting velocity of the heavily-loaded platform is between 17 and 18 ft. per min.

The greatest effective load that can be lifted is 31 tons, the pressure in the accumulator always 49 atmospheres, whatever the position of the loaded piston may be, and whether the lifting cylinders are at work or not. The pressure of the water in the lifting cylinder corresponds with the load

to be lifted; it varies between 11 and 39 atmospheres, for the unloaded platform, so that when loaded with 31 tons, if the platform is at the top of its lift, the pressure in the cylinder increases to 49 atmosperes.

ELASTICITY AND TENSILE STRENGTH OF WROUGHT IRON.*

By GEO. W. PLYMPTON.

Having occasion, a few years since, to test a large number of iron rods which were to be used in a Murphy-Whipple bridge, I found it convenient in some cases to extend the experiment so far as to determine the breaking strain, and also the highest tensile strain at which the elasticity remained unimpaired.

As the rods were designed for diagonal ties of a rectangular truss of 150 ft. span, the testing machine was of unusual dimensions. It consisted of a heavy framework formed of 2 pieces of pine 16 by 20 in., and 30 ft. in length. They were 18 in. apart. Heavy cross-pieces of oak at each end completed the framework or bed-piece.

The strains were applied by means of a screw 3 in. in diameter, working through a thick iron plate and one of the oak head pieces. The outer end of the screw was furnished with a ratchet-wheel, 12 in. in diameter, and a lever which worked on the extended screw as a fulcrum. A stout ratchet on the lever completed the movable outside portion at the head of the machine. Inside the head-piece, the screw terminated in a stout cast iron cross-head, in which it turned freely. The cross-head carried a pair of parallel flat bars, to which the rod under test was made fast. To facilitate the fastening, and to render the apparatus adjustable for testing rods of different lengths, the parallel bars were furnished with inch holes, 6 in. apart, exactly opposite in the 2 bars, and a sliding cross-head which could be firmly attached by pins at any pair of holes in the bars.

At the other end of the machine the strains were measured by a balance beam 10 ft. long. A 2 1-9 in. bolt, carried through the head-piece, was furnished with an eye on the inside end, and on the outside was (after being passed loosely through a thick iron plate which formed the end of the balance beam) forked so as to hold securely a steel block with a face at right angles to the axis of the rod; this face was made to bear upon a knife-edge when the machine was in operation.

The balance beam was constructed like a king-post truss, with an extra rod following the line of the inclined studs. At the end next the machine the plates above referred to were secured by bolts so as to form the extreme end of the beam. The plate had 2 blunt knife-edges, one on each side; the one towards the machine rested on a plate attached to the oak head-piece; the knife-edge on the other side, which was $\frac{1}{10}$ of a ft. higher, had for a bearing the steel block which received the strain of the rod under test.

To the extremity of the balance beam was hung a platform to receive weights. It will be seen that the tensile forces were therefore measured by a bent lever, whose arms were respectively $\frac{1}{10}$ of a ft. and 10 ft. The machine was designed by Mr. J. W. Murphy, of Philadelphia, and constructed under his direction.

The tests to which the great majority of the rods were subjected were made in accordance with the terms of the bridge contract, which required that the wrought iron rods should prove perfectly elastic under a strain somewhat greater than that to which they would be subjected when in place by the maximum load on the bridge.

As this computed maximum strain was supposed to be about $\frac{1}{5}$th of the ultimate strength, the tests were extended to $\frac{1}{3}$ or $\frac{2}{5}$ of the breaking strain. The rods, of course, extended under the strain; any rod that failed to recover its original length when the strain was released was condemned.

In order to verify our estimates of the ultimate strength, as well as to determine the limit of elasticity, an occasional rod was subjected to the proper tests. The results obtained under these conditions form the subject of this paper.

The measurements by which the extensions were determined were made with

* Paper read before the New York Society of Practical Engineering at the regular monthly meeting, Apirl 26, 1871.

a rod 10 ft. in length, and its measure on the rod under strain was marked with a knife-blade. The extensions corresponding to this length were carefully measured by a finely divided scale.

Many of the rods subjected to the breaking test were prepared for the experiment in such a way as to bring to trial the different modes of fastening at the ends. Some of them, therefore, had threads cut on stub ends welded on, some had threads cut on the original rod slightly upset at the end, while others were furnished with a turned eye only. Many rods showing a high degree of elasticity in the sound portion broke at a comparatively low tensile strain in the thread or weld.

The results of these experiments, as deduced from the tables prepared at the time, may be briefly summed up as follows :

(1.) The breaking strain of wrought-iron rods of American manufacture varies from 45,000 to 57,000 lbs. per sq. in. of section. A few of professedly poorer quality parted at 40,000 to 42,000 lbs. per sq. in. The relative tensile strength was slightly greater in the smaller than in the larger rods.

(2.) The extension of a rod under a gradually increasing strain varies directly as the strain up to the limit of the elasticity of the rod; beyond this limit the extensions are in a much higher ratio than the increments of tensile force. An illustration of this is furnished by the first case in my tables. A $\frac{3}{4}$-in. rod of "Howard" iron under a strain of 11,000 lbs. per sq. in. extended $\frac{13}{100}$ in. for 10 ft. in length; at 20,200 lbs. it had extended $\frac{22}{100}$ in.; at 26,450 lbs. its extension was $\frac{29}{100}$ in., and upon being relieved of strain recovered its length; at a strain of 41,600 lbs. its extension was 5 and $\frac{50}{100}$ in.; upon being relieved of strain, it set with an extension of 5 and $\frac{23}{100}$ in. The rod broke under a strain of 49,950 lbs.

(3.) The limit of elasticity under the circumstances which necessarily governed such a trial proved to be about $\frac{3}{5}$ths of the breaking strain; in no case lower than a half of it.

(4.) The amount of extension of the rod before reaching the limit of elasticity was in no case lower than $\frac{1}{410}$ nor higher than $\frac{1}{560}$ of the length.

(5.) The amount of extension which iron exhibits before parting varies greatly in the different brands, and bears moreover no discovered relation to the elastic limit or ultimate strength.

(6.) Although among the rods broken both kinds of fracture (granular and fibrous) were exhibited, no peculiar advantage could be claimed for either at strains below the limit of elasticity. Those which in breaking showed a fibrous character extended by far the most before parting.

(7.) A rod strained beyond its limit of elasticity and then laid aside for a time, proved (in each of several cases) upon repeating the test to be a rod of lower limit of elasticity than at first.

(8.) As a matter of curiosity, it may be remarked that the permanent set of an *overstrained* rod proved in the several cases to be its greatest length, under strain, *minus* its extension before losing its perfect elasticity.

(9.) The usual factor of safety employed by engineers, viz., $\frac{1}{5}$th of the ultimate strength, is well within the elastic limit, and is perfectly safe for bridges and roofs. It is, moreover, safe to test such rods up to the amount of proper working load before using them in the structure.

(10.) Although many rods from old bridges were tested in this series, no support for the popular theory that iron deteriorated under use could be gathered from our experiments. It may be remarked here that the late John A. Roebling, whose experiments were in progress about the same time, drew the same conclusion after a series of experiments upon a very wide range of varieties of wrought iron and steel.

The limit of elasticity would undoubtedly have appeared lower if longer time could have been allowed between the separate additions to the strain; but after a careful consideration of the published experiments, both in this country and Europe, it is believed that the practical conclusions drawn from the above tests are substantially correct.

THE Mount Cenis Tunnel is now nearly completed. The works on the Modane and St. Michael Railway are being pushed forward with the utmost possible activity.

THE APPLICATION OF STEAM TO CANALS.

By GEORGE EDWARD HARDING, C. E.

From the "Journal of the Society of Arts."

The immense capital invested in canal property, and the extended lines of inland navigation throughout the various districts of Great Britain, Northern Europe, and the United States of America, causes regret that, while so much has been done in past years to develop the trading interests of these countries, such extensive internal communications have been suffered to remain dormant, burdened by the same defective system of navigation which, once ample for the transportation of goods when the pack-horse and the country wagons were their only competitors, now is in most miserable contrast with the perfect system and dispatch that characterizes the management of the railways of the present day. The defects and delays in the transportation of goods *via* canal, not lessened by the private interests and conveniences of drivers, boatmen, and others engaged in their traffic, where heavy boats are dragged from one destination to another at the slowest possible speed by the wretched beasts that lean for support against the towing lines, point to the necessity of a radical change, to redeem them from the position to which they have sunk in the competition of the day.

Commencing with the early history of canals, we propose to present some of the more prominent experiments which have been designed to improve the construction of vessels adapted to inland navigation, and the application to them of mechanical means of propulsion.

Save that the large drains cut by the early churchmen in the Cambridge fens seem to have been employed for purposes of occasional inland navigation as early as the fifteenth century, the great commercial republic of Holland may safely claim centuries of European priority in the construction of a system of artificial water-roads which the industry of its people had turned to a good account of prosperity and power. France, Sweden, and even semi-barbarous Russia, had also taken the lead in this respect long before England had entered upon her career of canal construction, though in Egypt, long before the invasion of Great Britain by the Gauls, and in China, at a still earlier date, we know of their introduction, yet their origin is undoubtedly merged in the system of irrigation which, for unknown ages, has been pursued in those countries. Certain authorities have claimed that during the invasion of England by the Romans the works executed by them in the Fen districts were also used for navigable purposes, but of this we have no tangible proofs. In 1623, however, we find from Parliamentary records that Sir Hugh Myddelton was engaged in considering a bill "For the making of the River of Thames navigable to Oxford;" while, 23 years later, one Francis Mathew addresses to Cromwell and his Parliament a paper upon the immense advantages of opening up a water communication between London and Bristol, which purposed making the rivers Isis and Aire navigable to their sources, with a short canal to connect their heads across the intervening country; but, for Mathew's time, a scheme for the construction of 3 miles of canal, even by the State, was far too daring, and a century elapses before a canal is made in England.

Andrew Yarrington, gentleman, next publishes, in 1677, a curious book, entitled "England's Improvements by Sea and Land, to out-do the Dutch without fighting, to pay debts without moneys, to set at work all the poor of England with the growth of our own land," in which he strongly contrasts the prosperous energy of the Dutch, especially regarding their inland water communicaton, with the passive indifference of Englishmen to the immense advantages in their numerous streams and rivers, lying dormant at their very doors, wanting only improvement in their existing beds, with proper connection, to develop the trade and prosperity of the country.

To the lack of capital at this time can be traced the secret of the little progress of the internal communication of the country, and though Parliament liberally granted permission for river improvements, yet, from the want of money, few were attempted, or, if commenced, failed from the same cause.

About the beginning of the eighteenth century, the opening of the navigation of the rivers Aire and Calder gave a great impetus to the trade of that portion of Yorkshire, and stimulated the demand for improvements in inland navigation, and we find its first fruits in an Act of 1720, to make navigable the Mersey and Irwell, from Liverpool to Manchester; and, at about the same time, Acts for the improvement of the Weaver, Douglass, and the Sankey navigations were granted, and, what was more to the purpose, the works carried out. Again, in 1717, as a reference to the pamphlets of the British Museum will show, Dr. Thomas Congreve published some views, headed "A Scheme and Proposal for making a Navigable Communication between the rivers Trent and Severn, in the County of Stafford," which paper project slumbered for 40 years, till, in 1755, a survey was made for this very line of canal, under the auspices of the "Liverpool Corporation of Merchants," which line proceeded by Chester to Stafford, Derby, and Nottingham; and from Brindley's "Note-book" we find that he executed a fresh survey over the same ground in the years 1759–60, but at the expense of Earl Gower and Lord Anson.

Thus, it is not till the middle of the last century that English enterprise was fairly awakened to the necessity of a system of artificial canals; and directly traceable to the execution and extension of these earlier river improvements can we date the present system of internal communication, which has conduced so largely to the industrial prosperity of the English nation; and to the consequent increase of British manufactures and their distribution do all countries owe many of their indispensable comforts of life.

Apart from the deductions that would naturally follow from the river improvements, it is well known that, in 1755, the deepening and widening of the Sankey brook, tributary to the Mersey, with the application of a floodgate for retaining tide water, gave the hint which culminated in the construction of the well-known Bridgewater-canal, under James Brindley; but the rapidity of extension was afterwards such, that, between the years 1760 and 1803, no less than 2,295 miles of canal were opened. From the exceedingly interesting history of this Society, written by Mr. Davenport, we learn that the gold medal of the Society of Arts was awarded, in 1800, to the Duke of Bridgewater, as the father of inland navigation, and for his general exertions in promoting the interests of inland water carriage, since which date there seems to be no note of special award to the workers in this particular field of the economy of nations. Indeed, since the adoption of canals, except in the substitution of horses for men at the towing-lines, and some improvements effected in the manner of passing boats from one level to another, they may be truly said to have remained stationary in the general march of improvement, and, unlike all other arts, have partaken of none of the benefits arising from the increase of mechanical science. It is in the hope of calling attention to the fact, that by the exercise of a tithe of the mechanical ingenuity which has been expended on railways, canals might again assume a position and importance which, if not in general economy superior to railways, yet may, in relative utility, compete in the transit of minerals and other merchandise, that this paper is now before you, and the immense capital embarked in canals certainly renders it a subject of national as well as pecuniary importance. A further enumeration of the progress of canal construction in this country is unnecessary, yet a glance at the commencement of inland works in America will be interesting; and in connection we find, as early as 1724, Cadwalladar Colden, then Surveyor-General of the colony of New York, suggesting a system of works somewhat similar to those now existing. Sir Henry Moore, the Governor of the colony, in 1768, also recommended the improvement of the inland navigation. These recommendations slumbered through the Revolutionary War which followed, to be again projected with the independence of the country. As in England, the improvement of the existing navigations was first in course, and, as early as 1791, Acts for surveys and estimates relating to the removal of obstructions to the navigation of the Hudson and Mohawk rivers were passed. In the following year, the Western and the Northern Inland Companies were incorporated, and, by 1802, the former Company had succeeded in spending an immense sum of money, with but very small proportional results. The

route now occupied by the Great Erie Canal was adopted in 1812, repealed in 1814, to be again revived two years later. Ground was broken near Rome in July of the same year, while the first boat passed from Lake Erie to the Hudson in October, 1825, thus consuming a little over 8 years in constructing the distance of 364 miles, with a total of 71 locks. The Champlain Canal was commenced in 1816, and completed in 1823, since which date the many lateral branches of the Erie have been added to the system, and the application of inland navigation extended to many of the other States. It is a fact of interest that the original dimensions of these canals were established by the Commissioners in 1817, at 40 ft. in width by 4 ft. deep, with locks 90 ft. by 15 ft.; but as early as 1834, the wants of a growing commerce demanded an increase of capacity, and in 1835 an Act of enlargement of the Erie Canal was passed, since which time the depth has been increased to 7 ft., its width to 70 ft., and the locks to 18 by 110 ft. Before the commencement of the Erie, the cost of transporting a ton of merchandise from Buffalo to Albany equalled £20, and consumed 20 days; the canal at once reduced the cost to £4, or $\frac{1}{5}$th, and the time to 8 days. But mark, that the mere enlargement of the canal again reduced the average cost of movement, including all tolls, to 10 shillings per ton, or $\frac{1}{8}$ of the expense previous to the improvements. It may be interesting to review some of the more or less ingenious attempts to overcome the disadvantages of towing by horses, and hastily glance at the various methods of propulsion by mechanical means, which have been especially designed to supersede animal labor in propelling boats on inland navigable waters, in Europe and America, up to the present time. In this enumeration we shall necessarily find among the first experiments some which have been broadly designed for purposes of general navigation, and touch upon the early history of the steam-engine, but, so far as possible, preference will be given to those where application to canal or river navigation has been the paramount idea of their inventors.

In 1472, long before canals, attempts had been made to substitute for the manual labor of oars the propulsion of boats by wheels moved by oxen; while, on the 17th of June, 1543, with a precision of date which throws much doubt on the probability, the Spaniards claim the construction of a steam-moved vessel. Mention of galleys driven by side-wheels are found in the years 1578 and 1587; while, in 1618, David Ramsay obtained a patent from the Crown to apply engines "to make boates for the carriage of burthens and passengers runne upon the water as swift in calms, and more saff in storms, than boates full sayled in great windes;" and again, in 1630, was issued to him a second patent for a similar purpose. The many schemes for propelling boats which have been carried to a farther or less degree of experiment or practical use since Ramsay's day, are too curious not to be classified, and at the risk of tediousness, the manner and means for obtaining power of various kinds are enumerated :—From wind, by sails, kites, balloons, and windmills on deck; from oars, worked by men, animals, and steam; from paddle-wheels and screw-propellers placed in every possible part of the vessel, and variously constructed and driven; from the vessel's motion, and from the motion of mercury; from the current-operating machinery on board; from springs and from weights differently operated; from the explosion of gunpowder, and from gases, either generated or exploded; from the discharge of steam, compressed air, and from falling water. Electricity is to afford the motive power in 6 instances; while an endless chain lying upon the bottom of the canal, and passing over various parts of the machinery, has strong advocates. Some haul the craft along by a rope fixed on shore, and some again by a smooth or rack-rail on the banks, with which wheels driven from the boats engage. Thirteen sanguine inventors claim that a locomotive moving along the canal, and towing after the manner employed by horse-boats, is the only solution of the vexed question, while nearly as many believe that an atmospheric railway is the only system suitable. The larger number of workers in this field have affected the direct discharge of water at the stern as the greatest good, a less number by the discharge of air in various ways. One by discharging fire under water is peculiar, though hardly so curious as Congreve's device of sponges for propelling a vessel by capillary attraction,

forming a kind of perpetual motion. Several of the earlier motors were to achieve their end by thrusting poles against the bottom of the canal, two by water in a tube on the shore suitably connected with the boat. Bourne and others advise either wheels rolling on the bottom or the adoption of screws so working, which seem to have many disadvantages, but the action of reciprocating rods, armed with fixed floats or valved pistons, shaped as wedges, cones, or as hollow vessels, and worked at the sides or under the bottom of the boats, either in or out of channels, has always been a favorite plan, opposed again by a numerous class who allow the reciprocating motion, but insist that movable floats only can succeed. Variations of this last consist in hinged boards and collapsing propellers, operated in divers ways, while some, in their search for novelty, call all the others wrong, and place the floats at once upon an endless chain, by which they hope to use less power and gain more speed. Water or steam acting in flexible tubes end the list. Among all our counsellors whom shall we select? Some of these devices are deserving of more than such wholesale notice, and we will particularize a few of the more prominent. Passing over one hundred and fifty years, during which time we have the invention of the steam engine, and the early labors of such men as Papin, Savery, Jonathan Hulls, James Watt, and Symington, we reach the invention of Patrick Miller, who, in 1787, especially claimed an application of machinery for the purpose of inland navigation. His invention comprised either double or triple vessels, having two or three separate hulls, with one deck over all, with paddle-wheels, of any required number, placed in the space between the hulls, so as to be submerged to an advantageous depth. Originally designed to be operated by a capstan worked by a windmill or manual power, the arguments of Symington, who applied the steam-engine, changed the original idea of motive power, and successful experiments were made in the summer of 1788 and the winter of 1789, upon the Forth and Clyde Canal, where a speed of nearly seven miles an hour was obtained. Notwithstanding this success, it seems that Mr. Miller did not consider the invention as practical, since, in 1796, we find Miller again applying for a patent for the construction of vessels propelled by wheels worked by capstans, as in the original scheme. In 1788, John Fitch, an American, obtained a patent from the States of Pennsylvania, New York, New Jersey, and Delaware, for the application of steam to navigation, and also successfully opposed the application of James Rumsey for a similar patent the same year. Fitch succeeded in driving his steamboat eighty miles in one day, by means of six oars or paddles working perpendicularly on each side of the boat, similar to the strokes of the paddles of a canoe, but his invention came to no practical use. Rumsey, who had been refused a patent in his native country, came to England, and in November, 1788, obtained Letters Patent of Great Britain for propelling boats on rivers and canals, by alternately moving a valved box backward and forward under the keel of a vessel by means of his steam-engine. The box opened toward the stern, was provided with a valve at the forward end, which, opening as the box moved forward, allowed the water to pass freely, but, closing with the opposite movement, propelled the boat ahead. A second part of his specifications describes an arrangement for drawing water at the bow into a hollow longitudinal trunk parallel with the keel, and discharging the same at the stern by the reciprocating strokes of a large pump. Rumsey also devised two wheels projecting from the bow of a canal-boat, which carried an endless chain with floats. The current was supposed to actuate this mechanism, which, by operating a series of poles for pushing against the bottom of the channel, propelled the boat. The similitude of the plan with that of a man lifting himself over a fence by the straps of his boots is obvious. The death of Rumsey, in 1792, prevented any practical application of his inventions, though his associates, in the spring of 1793, obtained a speed of four miles per hour on the Thames, from a boat arranged upon his pump system as described, which boat Rumsey had nearly completed at the time of his death. Next in order, in the year 1801, Mr. Symington was employed by Lord Dundas to experiment, with the view of substituting steam for the horse boats on the Forth and Clyde Canal. After 2 years experi-

menting, and at an expense of over £7,000, the Charlotte Dundas was completed, and launched on the canal in March, 1803. In this boat were first combined all the principal features of our modern paddle-wheel steamers, viz., the double reciprocating engine, with connecting rod, and the crank on the axis of the rotary paddle-wheel. The paddle-wheel—for there was but one—was placed near the stern, in the centre of the boat. This seems to have proved a perfect success in regard to self-propulsion and towing of other boats; but though the efficacy of the system was proved, the opinion of the canal proprietors that the waves it created would damage the banks, prevented its adoption. Notwithstanding the decision of the Forth and Clyde managers, the Duke of Bridgwater, after a careful investigation of the advantages and the supposed drawbacks, gave Mr. Symington an order to build 8 boats similar to the Charlotte Dundas, to ply on his canal, but the death of the Duke, soon after, prevented the execution of the scheme, and poor Symington and his canal navigation were neglected together. The ingenious experiments of Stevens, Evans, and Fulton, in America, about this time, being applied for purposes other than canal propulsion, do not particularly concern this narrative, for although, in 1796, Fulton published in London a treatise on canal navigation, wherein he advocates raising and lowering of boats by means of inclined planes, yet he makes no mention of steamboats therein, though in January, 1803, he described some experiments with paddle-wheels as more advantageous than the system of chaplets or endless band of floats for propelling a system of boats, which were designed to be formed with bows and sterns convex and concave, so that several would form a line with almost continuous sides. Yet he does not seem, even after his practical success on the North River in 1807, to have again advocated steam for canal uses. In later years, this arrangement of boats has been revived again and again. Richard Trevethick and Robert Dickinson took out a patent in 1809 for moving an oar, provided with valves, forward and backward in a channel under a boat; and 2 years later one Rose received a patent for constructing a canal boat, with water-courses open to the water below and at each end, with 2 or more paddle-wheels and cranks acting on the water. No drawings are known to be in existence of these plans. In this same year were also granted 2 patents for propelling boats by discharging water at the stern by means of a steam pump, similar to Rumsey's principle, but no experiments are noted. In 1812, but 1 patent was issued for improvements in canal navigation, where endless bands traverse over wheels at the end or sides of a vessel, and carrying hinged floats to act on the water when propelling the boat, but caused to lie flat on the reverse stroke in a manner not plainly described. In the following year, we find an invention by Thomas Mead, who proposes a double endless chain moving around 2 wheels above and below 2 parallel tubes; on the chain belt are a series of pistons packed so as to pass steam-tight through the tubes. Steam from the boiler forces the pistons continuously along one tube, at the end of which they are successively detained and released by catches, and pushed forward a small distance by eccentrics. The steam escapes by a hole in one of the tubes, which is uncovered at proper times as the pistons require. In 1815, Richard Trevethick patented a screw propeller, consisting of a worm or screw, or a number of leaves placed obliquely round an axis, which revolves, preferably, within a cylinder at the head, sides, or stern of a vessel. In some cases the screw is to be made buoyant, and works in a universal joint, the advantage of which construction is hard to perceive. John Millington, during February of the year 1816, lays claim to a propeller more modern in its features than any preceding. He also claims forcing air into tubes, which operated against the water at the stern to propel the boat. In the same year, we have an arrangement with several cranks on the side of a vessel connected with each other by horizontal connecting-rods, upon which are placed vertical vanes of a curved shape, so as to act upon the water by the revolution of the cranks one way (but carried forward above the surface); and in the next a method of propulsion by operating oars, held vertically at each side of the boat, in a similar manner to Fitch's earlier experiments, except that, by means of cog-wheels, the oar blades were feathered to pass edgeways through the water during the return stroke. About

the same date, Niepce proposes propelling a boat by the pressure on the water of the gas and rarefied air produced by the inflammation of the essential oil of resin injected at intervals into an air-reservoir and there ignited. The gasses pass through tubes provided with valves into a well, from which they expel the water with force along a tube opening below water-mark at the stern of the boat. By the use of 2 receivers, and by spiral blowers refilling the air-reservoir, the propulsion is effected more evenly.

In 1818, John Scott patented an arrangement by which forked poles, operated by wheels, push against the bottom of the canal, and, in case the depth is unusual, broad vanes at the ends of the poles thrust against the water, and are lifted into the air for the return. We also find in this year hinged floats fixed to a reciprocating chain under the vessel. Two years later, George Lilley and James Fraser recommend the application of a forcing-pump to constantly supply water to a cistern upon the deck of a boat; while, by means of a condensing air-pump, the pressure of the air in the cistern is increased until the force of a stream of water, conducted from the bottom of such cistern to the stern of a boat, shall drive the vessel forward. Vanes driven by an engine, and oscillating through part of a revolution in an air-tight cylinder or drum floating upon the water, are also found to propel a boat, by alternately receiving water at one side of the vanes and discharging it from the other; and, in this same year, a sanguine inventor claims applying the paddle-wheels astern, or in the rear of the vessel, and so arranged that the part of the vessel which carries the machinery may be separated and applied to the stern of any number of vessels in succession to propel them. The next year, we have 4 inventions. The first places the propelling wheels in a horizontal position at one side of the deck, with the floats feathering as they return, folding against the periphery of the wheel by means of suitable levers, cog-wheels, and inclined planes, and thus prevent resistance to the water. The second revolves one or more pair of paddle-wheels in channels or sluices in the vessels, whilst the third, disdaining the aid of steam, operates his paddles entirely upon the treadmill system. The last is a repetition of the endless chain and floats. In 1822, the Brothers Binns claim the application of a rotary steam-engine with wheels feathering the floats by reason of loading the bottom edges of the paddles proportionate to their surface, which hardly seems certain in action at even a medium rate of speed, and a few months after, we have one of the earlier claims for increasing speed by the use of geared engines, though not specially claimed as applicable to inland navigation. In February, 1824, Moses Isaacs, whose name inclines us to the belief that he was of Jewish extraction, patents a swinging "fiery" furnace, which alternately heats 3 boilers, while the steam from the cylinders is received by the boilers first heated and now cooling. This scheme is decidedly visionary. An "ichthyodic oar" is next claimed by one Busk, which he describes as a "wedge between 2 planes under water moving back and forward, turning on an axis through its thick end, and so as to touch with its sides each plane alternately. Valves admit the water, and close when the wedge forces the water against them. The oblique pressure of the sides of the wedge on the water propels the vessel. In a modification of the above, a wedge is caused to move up and down in the water with its thick end forward and its edge horizontal, and includes in the specification revolving cones, with their axes horizontal and points turned towards the stern. He also presents as a novelty the pumping of water through tubes which, in his fondness for original names, he baptizes as a "Hydropetic propellent," and the very next month, in partnership with James Neville, he desires protection for drawing along a boat by opening and shutting planes fixed at the bows after the manner of the covers of a book, and also claims forcing air through tubes against the water. Two months later this same irrepressible William Busk appears as the inventor of a method of propulsion evidently taken from the action of the tail of a fish. An elastic plate, fixed at one end to an axis, is caused to vibrate back and forward in the water, or two such plates revolve from a projecting shaft at the stern; but Busk, with all his ingenuity of devices and nomenclature, does not appear to have realized either fame or fortune, and he subsides for a couple of years, when he brings up two

other arrangements quite as theoretical and impracticable as any that preceded them. The first record of invention in which a chain lying in the water of the canal, fast at one end, and passing round a wheel on board the vessel, which wheel being turned by machinery, the boat is propelled, leaving the chain behind on the bottom, is found in Samuel Brown's claim of March 15th, 1825, and is worthy of note, having been revived at various periods, and even reported at the present time as in use in Holland. The disadvantages of this system in regard to passing locks and bends of the canal, militate against it. As a modification of this principle, we were lately shown a plan whereby a heavy chain was tried on the Bridgwater Canal, but instead of using a direct pull as the propelling power, the chain was taken on board over the bow, and lowered, with considerable slack, vertically over the stern, the gravity of the hanging loop being expected to move the boat forward. It is unnecessary to add that this failed as a practical means of propulsion. In this year John and Samuel Seaward patent the employment of a wheel or wheels placed in an opening or well through the bottom of the boat, and revolving upon the canal bottom, or against the sides thereof, and by that means to propel or draw the vessel forward. These wheels were provided with projecting knobs on their peripheries, in order to take a firm hold of the ground, or, if desired, projecting arms or radii could be used, in which latter case the arms were arranged to slide in and out of hollow spokes, so as to freely compensate for inequalities of the bottom. We can imagine some difficulties and considerable mud involved in the practical solution of this problem. Next year we have paddle wheels at the bow or stern, which lift on deck for convenience in lockage, and also the employment of kites for drawing vessels; the multiplication of these kites was to give "indefinite power," and very indefinite it would be surely, not perhaps in the sense intended by the over-sanguine inventors. Congreve's device we have already mentioned. This patent, issued in 1827, comprises a broad, thick band of sponge around a cylinder free to revolve in the water. The water rises into this band on one side by capillary attraction, and an endless chain compressing the band by its weight on the other squeezes the water out. The difference in weight between the two sides causes the cylinder to rotate and to draw the vessel on, or to move paddles to propel it. Glass or metal plates may be used to create the capillary attraction, and mercury in a tank instead of water. No boats on this system are known to be in use. This year also brings out an invention for propelling boats by setting in motion the system of levers commonly known as "lazy tongs," and probably intended to have hinged floats at its extremities; and three months later an idea is made public where hinged vanes, obtaining their reciprocating motion from rocking shafts, are employed. In 1829, two spirals at the stern of a boat, and covered by removable plate iron cylinders, to protect the banks from injury, is claimed by Julius Pumphrey; in 1831, a scroll-shaped propeller, revolving in a scroll-shaped case, by William Hall; while, in 1832, Woodcroft patented his increasing pitch screw-propeller, applied at the side or at the stem of a vessel or boat; but what Fulton did for the paddle-wheel in America, and Bell in this country, namely, its practical introduction, we must award to Ericsson in respect to the screw-propeller. Captain John Ericsson, as the first actual demonstrator of the submerged screw-propeller, in 1837, has afforded us a means for propelling boats on narrow water-ways, without the disadvantages arising from the use of paddle-wheels operating upon the water surface; for although, besides those lately mentioned, Bramah, in 1785, patented a propeller on the principle of the sails of a windmill or the blades of a "smoke-jack," Littleton, in 1794, Fulton in 1798, and Edward Shorter, in his claim for "a perpetual sculling machine," in 1800, yet to Capt. Ericsson is due the credit of the first successful improvement, carried out in May, 1837, on the John O. Sergeant, with a double propeller, though his patent is dated nearly a year previous. The success of this steamer induced the construction of the Robert F. Stockton, which, though provided with a double propeller similar to the Sergeant, was as frequently worked with one only. After several trials of her powers in England, she crossed the Atlantic in 1839, where she was at once sold to the Delaware and Raritan Canal Company for towing their

boats. The value and importance of the screw to navigation having been clearly demonstrated of practical value, a number of screw boats were put on the lines of inland navigation which connected Lake Ontario and the St. Lawrence *via* the Welland Canal, and also on the route of the Chesapeake and Delaware Canal, which united the Chesapeake Bay and the southern waters with the river Delaware and the north. As instancing the capability of canals even in competition with railways, we find, according to Woodcroft, that the introduction of the small screw steamer, the Ericsson, between Philadelphia and Baltimore, by the inland route of the Chesapeake and Delaware Canal, completely ruined the goods traffic of the Philadelphia and Baltimore Railway. In the competition with this single vessel, the railway was compelled to reduce its passenger fares one half, and even with the attempted aid of the State, it lost its entire freight business. Capt. Ericsson also built, in 1839, an iron screw propeller, named the Enterprise, to run as passenger boat on the Ashby-de-la-Zouch Canal, but the introduction of railways prevented her being profitable for this purpose, and she was afterwards used to tow coal barges on the Mersey and Trent navigations with entire success. Returning to our inventors, we find Sir John Scott Lillie patenting, in 1836, the application of atmospheric railways for towing canal boats, but the practical inconveniences which have hitherto prevented the use of locomotives along the canal banks for the same purpose would hold ground as strongly here. Intending to overcome all objections, an enthusiastic American started a joint stock company, about 2 years since, for the purpose of constructing an elevated double railway over the line of the Erie Canal and its branches, from which the boats underneath could be towed at any speed; but the estimates of costs certainly exceeding $4,500,000,while the dividends were not so positive, there yet remains opportunity for English subscribers to invest. However, this only goes to prove the awakening to the necessity of applying to canals some of the attention and improvements so liberally bestowed on all other carriage systems, and, sooner or later, a fortune will reward the lucky inventor who shall solve the great problem of canal propulsion. In case of the ordinary shaped boat being dragged along the canal by steam towage, any increase of speed, commensurate with the expense incurred, will create a wave more destructive to the banks than the use of an ordinary propeller, so that any system of railway towing requires the adaptation of a complete fleet of boats specially devised for high speeds with small resistance. For the tables on the resistance of canal boats at different speeds, and the disturbance of the water surface, reference is advised to the experiments of Stevenson, in 1818, Beran in 1832, of Palmer, as published in the first volume of the "Transactions of the Civil Engineers," with Professor Barlow's report thereon, and those conducted by McNeil on behalf of the proprietors of the Forth and Clyde Canal.

This paper would be incomplete without mention of the experiments of Fairbairn, in 1830 and 1831, as instanced in his "Remarks on Canal Navigation, illustrating the advantages of steam as a moving power on canals." The preliminary experiments of light single and double gig boats on the Forth and Clyde Canal, moved at a high rate of speed and variously loaded, as well as the partial success of the steamer "Cyclops," built under the direction of Mr. Grahame, of Glasgow, with a single stern paddle-wheel, induced Mr. Fairbairn to suggest the construction of a small steamer named the "Lord Dundas," 68 ft. in length by 11 ft. 6 in. in breadth, and 4 ft. 6 in. in depth, provided with a wheel through 3 ft. 10 in. wide, and a paddle 9 ft. in diameter, driven by a 10 horse-power steam engine; but he also recommends as an after improvement, a steamer with two narrow paddles, close to the stern and on each side of the rudder, urging that this plan would remove every impediment to the free access of water to the paddles, and allow an open outlet for the discharge, the paddles to be protected by fenders, sliding down on the outside of the wheels. Mr. Fairbairn figures the cost of conveyance of a passenger by steamer between Edinburgh and Glasgow, 56 miles, at 2d., or less than $\frac{1}{15}$ of the least possible expense by horses. Though the results given by these boats were not in practice so satisfactory as expected, yet Mr. Fairbairn never despaired of a future when steam should be as universal in

inland navigation as it at present is in all other of the arts.

Following up the interest which about this period seems to have been excited on canal behalf, we have an influx of applications of machinery to inland water propulsion, many of which are but modified forms of the less elaborate devices we have already mentioned, in which the paramount idea of their authors would seem to be that of advancing the boat without creating a wash damaging to the canal banks, and with arrangements for discharging the water directly aft or directly down, while some have curved platforms, or "*wave quellers*," to moderate the swell produced by the propelling machinery.

For actuating vessels on canals, one Henry Pinkus submits a railway constructed alongside, with one rail, on which a suitable carriage traverses. A tube conveys gas along the rail from a stationary engine and reservoir. The gas is brought through a longitudinal valve on the rail tube to a flexible tube from the carriage to a reservoir on board the vessel, and from the pressure here derived machinery is set in motion, which again, by an endless band, turns two horizontal wheels (one on each side of the rail) on shore, and supported on the carriage before mentioned. Finally, these wheels, by revolving, draw the carriage forward, and the carriage, in its turn, tows the vessel. We can imagine that this plan would never depend upon its simplicity for success. The same inventor offers the plan of a steam-engine on a vessel driving a horizontal wheel, which, by an endless band, turns on shore a pair of horizontal wheels similar to those described, and these, by revolving, tow along the vessel. The carriage holding these wheels has a curved guard arched over it, formed like the rail on which the carriage runs. This is to enable another carriage meeting it to pass over the first, thus providing for the use of the same rail by boats travelling in opposite directions. In place of the steam-engine, the machinery on board may be turned by an electro-magnetic engine, actuated by electric currents from shore. Whether this "leap-frog" arrangement for passing-boats could be extended to skipping playfully over the locks, is not stated.

A claim, in 1841, proposes a locomotive steam engine on the towing path to drag itself along a chain fixed at one end, and the boat by a towing line to the engine; while another alternately expands and contracts an elastic sack in a water channel along the bottom of the vessel by the smoke from a furnace, and thus ejects sufficient water to propel the boat. Later on, there are variations of this. Still another drives an upright shaft in a vessel which carries a horizontal grooved wheel, on which is an endless rope, moving a drum on a carriage on shore, by which its wheels are turned, so as to advance the carriage, which then tows the craft along. The carriage is guided by a wheel in front, directed by a man. Steam is made to issue from a pipe against the air in one, and cog-wheels working into a rack-rail on the banks in another, while a third places an exhausted atmospheric tube at the bottom of the canal, and moves the boat above by a travelling piston. A fourth inventor makes his tubes of wood, and places them upon the banks or on piles driven along the canal. In fact, "about this time," as the almanacs say, the numbers that considered themselves each the sole possessor of the idea of working canals by atmospheric pressure is amusing. In 1847, we have flexible tubes placed under water on each side of a boat. They are alternately filled with steam and allowed to collapse. The boat is supposed to advance by the action on the water of the protuberant parts of each tube. There is certainly no needless complication of details about this. In this year we find proposed the towing of canal boats by compressed air contained in portable reservoirs, and an arrangement added to heat the air, in order to restore the caloric lost by its expansion. The next year, a patent is granted for a tube laid along a canal, and water forced through it under pressure, enters nozzle pipes, fixed at certain intervals along the tube. Connected to the boat to be propelled is a receiver, with a series of open cells, and as these pass under the end of a nozzle-pipe a valve is opened which allows the water to impinge on the cells successively, and thus force on the boat and the receiver, until they set the next nozzle-pipe in action, and close the valve of that which is passed. Still, notwithstanding the ingenuity of this scheme, one would desire much soli-

citation to invest in its success. Next, we have a shaft extending the entire length of the vessel, with propellers on its projections working one at the bow and one at the stern. The advantages of this novel feature are not mentioned. The last of 1851, a patent for fastening iron rails upon walings, supported on piles, and extending the entire length of the canal on both sides was issued. Wheels on each side of the boat, and driven by a steam engine, are rotated on these rails and pull the boat. Instead of locks, the boats move up inclined planes, gear wheels engaging in racks on the walings, while rollers at the bottom support part of the weight. Unless compensated for all variations of water level we might, expect to find occasional lines "high and dry." In 1856, a provisional is filed for propelling boats by discharging a stream of fire from an inflammable composition in a tube into the water at the stern, but from want of faith or of means, the scheme was abandoned. At a later date, John Bourne patents an arrangement of propellers at the bow, or paddle-wheels at the side to work on the bottom in shallow water, "and thus clear it away" and propel the vessel.

With their usual ingenuity and perseverance, American inventors have explored this branch of engineering practice, but, like their Translantic brethren, have taken the question of mere propulsion as the desired end, attaching thereto some device to still the agitation of the water, and very similar schemes in this field to those already touched upon have been the result of their labors. The question is not that of a motive power alone, but simple application of the motor that will prevent waves at the bow, suction and settling at the stern, and afford a mean speed of from three to four miles per hour when fully loaded, with a minimum quantity of fuel. The propelling machinery must be simple and compact, that it may be managed by men not especially educated for the purpose, to economize both space and expense. These are the requisites, and a boat fulfilling the conditions will be sure of success.

Some 25 years ago, Captain Ericsson launched a boat with a screw propeller at each side of the bow for the Champlain Canal. There was no difficulty in the propelling force, but it did not carry sufficient cargo to be profitable. Henry R. Worthington, 5 years later, ran a steam canal-boat from New York to Oswego during one season. This vessel had a skew paddle-wheel on each side of the bow, and a *fighting crew* to overcome any *prejudices* which the opposition boatmen should venture to express. Notwithstanding the *extreme force of the arguments* employed, the enterprise was abandoned with the season, there not being sufficient capacity for a paying freight. A boat was fitted with feathering side-paddles, some 16 years ago, by John Baird, for the purpose of towing barges on the Erie Canal, but not carrying cargo itself, and depending on the tonnage fees from the old boats, failed to be a pecuniary success. In 1860, there was a line of sharp propellers built in Buffalo, New York, which, with an expenditure of from 3 to 4 tons of coal per day, averaged 6 and 7 miles per hour. The annoyances caused by the opposition of the horse-boats, and the heavy expenses of fuel and engineers, caused their removal to a lake route. Wire rope traction and submerged chains have been frequently tried as well, and found wanting, the canal locks and numerous bends having so far proved insurmountable obstacles.

As late as last year, the duck-foot, or expanding propeller, so many times tried in England, was attempted in Albany, New York, by Mr. Cornelius T. Smith, and also at Cumberland, Ind., by Mr. Marshall, without satisfactory results; while a Cincinnati doctor, abandoning his pills, conceived that he had hit upon the correct thing by the similar device of a reciprocating hinged shutter. The result made more noise and waves for the canal than greenbacks for his pocket, and our worthy disciple of Esculapius returned to his surgery. At Lockport, New York, a wheel with spokes on the surface, made so as to rise and fall in a recess in the boat, and rolling along the bottom of the canal, was lately tried. It was driven by a chain, and so propelled the vessel. No provision for deep water or soft mud being made, this enterprise came to grief. A scheme now being tried consists of a canal tug-boat provided with an endless band or chain on each side of the boat, carrying paddles, which, dipping in the water to propel the vessel, return through the air in a manner akin to similar plans

which have been tried here and abandoned. There has been a large sum of money expended, and a frightful noise is produced, still otherwise it is not considered a success.

We close the list by calling attention to the arrangement for applying steam-power to canal-boats, which has been recently designed and practically operated in the United States by Mr. Thomas Main, mechanical engineer, of New York, and presented in longitudinal section and plan on the diagram. It will be seen that it possesses all the happy features for obtaining propulsion by steam on narrow channels, for which many have striven, but none before fully accomplished; but, as has been justly remarked by a modern writer, "an invention is progressive in a regular series." There may be a long order of elementary principles developed without the occurrence of a single practical result, so far as any useful application is concerned, but the perfect machine will be found by somebody. Analyze the diagrams, and there will be found a propeller placed in the bow of the boat (its advantages are readily seen), woking in a channel underneath the vessel. The peculiar sloping of the channel is the most convenient arrangement for overcoming any tendency to create a wash, which has been, in some form or under some name, the object of several inventions. The high pressure machinery and tubular boiler is the very locomotive engine so strongly urged by Mr. Fairbairn, only in this instance the inverted cylinder and upright boiler economize the space to the utmost. In fact, the general position of both the channel and the motor interferes least with the cargo-bulk, and the water, after passing the propeller, is deflected in the line of least resistance. and passes under the entire length of the boat to form scarcely a ripple upon the surface, while the channel sides are a safeguard against any lateral waves. It may be asked if the peculiar shape of this channel does not cause friction of the water, and great loss of power. This would certainly be inconvenient in any case of high speed, but in the slower movement of canal traffic, we shall not find any appreciable loss from this cause. A boat constructed on this principle has been for some time regularly employed upon the Erie Canal in America, carrying, besides the machinery, 200 tons of cargo at a rate of 3 miles per hour, including lockages, or 72 miles in 24 hours, consuming only a ton of coal at $5, against $28.50 for 2 days' horse towage, for the same distance—a saving of half the wages of crew, and transporting the goods in the same proportion of time —and additional to its own cargo, can tow a similar loaded barge at very nearly the same speed. This boat can go through a lock in 6 min., against 12 min. required for a horse-boat, and is then handled by one man with ease. There is no injurious action on the banks, and the boat can leave the canal, and proceed as quickly and safely on river navigation with her self-contained power. In 12 months, such a boat, 70 ft. long by 16 ft. wide, and 9 ft. depth of hold, with an 8-in. cylinder, driving a $4\frac{1}{2}$ ft. propeller, can pay for her entire cost from the saving over horse-boats, to say nothing of the certainty and despatch which alone insures the confidence of the mercantile community, and is the foundation of extensive patronage. Every comparison between the expense of steam *versus* horse-carriage, that is attainable, gives great economy to the former system; and sooner or later, with her canals enlarged, and steam-propelled boats giving a system of trackage infinitely superior, cheaper, and more regular than anything hitherto dreamed of, England's internal navigation will take a position worthy of those talents that conceived them. The party of croakers who are ever found in opposition to improved communication, will, with the present *employés* and certain railway interests, loudly cry out against any innovation trenching on this special province, and predict sad disaster to the country by any interference with the ancient customs now cherished so fondly; but if the step is not now taken in the spirit of enterprise, it will be forced upon the country as a necessity, after other nations shall have led the way. Notwithstanding the immense amount of freight conveyed by railways, now burdened nearly to their utmost limits, we find trade, with its gigantic strides, tasking the carrying capacity of the canals in spite of their many disadvantages, and ever steadily increasing in its demands. In 1835, before the opening of the London and Birmingham Railway, the through tonnage conveyed on the Grand Junction

canal was 310,475 tons, and in 1845, after ten years opposition of this road, the tonnage had increased to 480,626 tons; while, at the annual meeting of the canal proprietors in 1860, the receipts for the previous six months had been the largest ever experienced.

America, at the present moment, is alive to the necessity of canal improvement. Nearly £4,000,000 have recently been recommended by the Canadian Canal Commissioners for the enlargement and construction of slack water navigations. And, within a few weeks, the Legislature of New York have introduced a bill, offering a reward of $100,000 for the best plan of canal navigation, in the substitution of steam or other motive power for animal labor; and England should not remain backward in the race, especially since to her canal system she owes so much of her present prosperity and greatness.

The cumbersome barge, with snail-like advance, feebly contrasts with the iron horse, thundering by with its speed and power. Yet, improved as they should and must be, canals will always continue to form an essential part of internal communications, to be missed quite as much as roads, railways, or even the telegraph itself.

In conclusion, the author expresses his sincere regret that this glance at the canal system, and the mechanical methods which have been suggested as applicable to the propulsion of their boats, had not fallen into abler hands. Its compilation has been gathered from many sources and authorities, with but limited time spared from usual avocations. But trusting that it may at least draw attention to a most important field in the economy of nations, such as it is, this paper is presented in the hope of a favorable reception.

ON THE PRODUCTION OF ALLOYS OF IRON AND MANGANESE, AND ON THEIR APPLICATION TO THE MANUFACTURE OF STEEL.

From "The Journal of the Iron and Steel Institute."

The properties of pure alloys of iron and manganese have not, as yet, been completely investigated. It is assumed by many metallurgists that the presence of a sensible proportion of manganese in malleable iron or steel, improves the ductility and elasticity of the metal, and that for this reason the addition of manganese is indispensable for the production of good cast steel. Other metallurgists, on the contrary, maintain that manganese has a tendency to produce hardness and great cohesive strength, at a sacrifice of those properties of malleability and ductility which are principally looked for in all modern kinds of "soft steel." According to this latter view, the function of manganese in steel making is simply to remove all surplus oxygen and silicon from the mass, and (in combining with these noxious elements) to disappear from the metal and pass into the slag.

This difference of opinions with regard to the theoretical position of manganese in the process of steel manufacture, does not preclude an absolute unanimity amongst steel makers in this country and abroad, as to the practical necessity of employing manganese in the manufacture of cast steel. In the old process of melting blister steel in a crucible, the addition of carburet of manganese—as patented by Josiah Marshall Heath in 1839—or the addition of an oxide of manganese mixed with a sufficient quantity of carbon for the final reduction of the manganese, are practised at the present day. The only modification which has been effected in recent years with regard to this process, is the substitution of spiegeleisen, a substance which may be considered as an alloy of carburet of iron and carburet of manganese, instead of the pure carburet of manganese originally employed by Heath. In the Bessemer process, the addition of an alloy of iron, carbon, and manganese, is an essential element of practical success, and a similar employment of manganese alloys has been adopted in the Siemens-Martin process, and in several other modern methods of steel manufacture.

The reduction of pure manganese from its ores, or the production of a pure carburet of manganese, presents considerable practical difficulties. The great affinity of manganese for oxygen, and the readi-

ness with which the oxides of manganese combine with silica to form a slag which is liquid at a comparatively very low temperature, render every process for reducing metallic manganese extremely difficult to conduct on a large scale, and very expensive in practice. The production of metallic manganese has, therefore, never been successfully carried out in commercial practice; and it appears that Heath himself abandoned his original idea of manufacturing carburet of manganese, and preferred to charge the steel-melting crucibles with oxide of manganese and carbon, on account of the saving of expenditure attained by this change.

The principal supply of metallic manganese for modern steel manufacture is obtained in the form of alloys of iron and manganese produced by a variety of processes, and differing in their nature and qualities to a considerable extent.

Alloys of iron and manganese are reduced from natural or artificial mixtures of the ores of both metals with all the greater facility the higher the proportion of iron, and the smaller the percentage of manganese is required for the product. The ordinary pig iron produced in the blast furnaces of Sweden, Austria, and many other localities, contains from one to three per cent. of manganese. This is due to a small percentage of carbonate of manganese in the spathic iron ores of these localities, and it is a mere question of the quantity of silica present in the slag which determines the exact percentage of manganese which is reduced and brought down with the metal.

A specialty of such pig iron which contains a proportion of from 7 to 11 per cent. of manganese is the well-known spiegeleisen from the district of Liegen, in Rhenish Prussia. This pig iron is made from a spathic iron ore, which is a crystallized compound of carbonate of iron and carbonate of manganese, and which occurs in a large vein in a mountain called the "steel mountain," at Müsen. The production of spiegeleisen, however, requires a particular management of the furnace; it is necessary to protract as much as possible that part of the smelting process which is destined to the carburization of the reduced metals, and for this reason the charges must be so managed that the ores are quickly reduced, but that a long time is afforded to the reduced spongy metal before actual fusion takes place. The iron must be carburized at a temperature which is not sufficiently high for the reduction of silicon from the slag, yet at the same time the temperature at which manganese is reduced from its ore is nearly as high as that which will allow the silicon to pass into the metal. The presence of a considerable percentage of silicon, however, would prevent the production of specular iron, since the presence of silicon in molten iron has the tendency to drive the carbon out of its state of combination, and change it into graphite. The iron, instead of being specular, would become gray or mottled according to the temperature of the furnace, and its properties would be different from those of the spiegeleisen proper. On the other hand, if the temperature of the furnace is too low, or the time required for the carburization is too short, common white iron will be produced containing only a small proportion of combined carbon, and very little manganese.

The principal art in making spiegeleisen consisted formerly in making the ore capable of quick reduction by calcination, using burnt lime and only a small quantity of clay slate as flux, in order to reach the stage of carburization as quickly as possible, and applying cold blast and charcoal in order to keep down the temperature of the zone of fusion, and thereby protract the preceding stage to the utmost extent possible. With recent improvements and the necessity for economy, the ironmasters of Liegen have learnt to make spiegeleisen with hot blast and coke, with utilization of waste gases, and a high temperature in the zone of fusion. This is done principally by keeping out the silicon with an overdose of burnt lime, which also assists in preventing the sulphur from the coke from acting injuriously upon the iron.

With all these precautions, however, it is not possible to produce speigeleisen at all times and continuously in the same furnace. Fluctuations in the temperature and pressure of blast, and similar apparently very slight causes, will suddenly change the produce from spiegeleisen into gray or mottled iron, if the heat is excessive, or the slag too rich in silica, or the coke too much contaminated with sulphur; or common white iron will be produced if the temperature gets too low, or the bur-

den too heavy. With the best managed blast furnaces, intended specially for making spiegeleisen, only 70 to 80 per cent. of the total annual produce is iron of that class, the remainder being either gray or white, according to the side to which there is a greater liability of error in the particular furnace.

The proportion of manganese in the spiegeleisen from the Liegen districts rarely exceeds 10 per cent., and the average percentage of manganese in this material is about 7 per cent. The quantity of combined carbon in the spiegeleisen is almost constant, and amounts to 5 per cent. In adding a dose of spiegeleisen to a charge of decarburized iron it is, therefore, unavoidable that a proportionate quantity of carbon must be added for any given quantity of manganese which it is desired to introduce into the charge; and this leads to a difficulty in making very soft kinds of steel, which has always been very seriously felt by all Bessemer steel makers, and has been overcome only to a certain extent by great experience in the management of the converter. The actual necessity for making very soft steel with Liegen spiegeleisen is to "overblow" the charge to such an extent that there is oxygen enough left in the metal to combine, not only with all the manganese and silicon, but also with the greater part of the carbon introduced by the spiegeleisen. This practice has made it possible to apply ordinary spiegel to the manufacture of the softest kind of Bessemer steel; but it is an acknowledged make-shift, which has numerous well-known disadvantages, and the demand for richer alloys of iron and manganese has, for a long time past, been felt and acknowledged by every steel maker in this country.

Mr. Henry Bessemer was the first to point out this demand publicly in his specification for the manufacture and application of a so-called triple compound of iron, manganese, and silicon, instead of the ordinary spiegeleisen, to the manufacture of Bessemer steel. The mode of manufacture of this triple compound, as indicated by Mr. Bessemer, has been practically carried out by Mr. Prieger, of Bonn, and alloys of iron and manganese reaching occasionally as high a proportion as 60 per cent. of manganese have been produced by this process. The mode of operation is understood to be as follows: A graphite crucible is charged with a mixture of granulated cast iron, peroxide of manganese, and powdered bottle glass, and to this a large proportion of powdered charcoal is added. The reduction of the metal takes place at a very high temperature, and the alloy is richer in manganese in proportion to the heat. This process has been taken up by several steel makers, but has been finally abandoned on account of the excessive expenditure which this mode of manufacture involves.

Another process for the manufacture of ferro-manganese has been invented and patented by Mr. Wm. Henderson, of Glasgow. The claims of Mr. Henderson's patents are embodied in several specifications filed between the years 1860 and 1869. The manufacture of ferro-manganese seems to have been intended by the inventor to form only an accessory part of his method of metal extraction, which is described in his numerous patents. This process has been at work for a considerable time at the Phœnix Foundry, in Glasgow, by Messrs. Thomas Edington & Sons. It consists in reducing upon the open hearth of a Siemens furnace a mixture of carbonate of manganese and oxide of iron, in the presence of an excess of carbon, and by means of a neutral or reductive flame. The furnace bottom is carefully prepared from ground coke, consolidated and baked up to form a solid and durable carbon crucible on a large scale. The charge of oxides is ground up to a fine powder, and intimately mixed with powdered charcoal or coke, and the whole mass when charged and heated to a red heat for several hours becomes converted into a metallic sponge containing the reduced metal from both oxides, which is capable of being run down into a regulus by elevating the temperature to a full white heat. The quantity of manganese reduced in this manner is principally dependent upon the high degree of temperature given to the metallic bath at that stage of the operation. For this reason, and also on account of the necessity to avoid an oxidizing flame, the Siemens furnace is indispensable for this mode of manufacturing ferro-manganese. With all precautions, however, it is not possible to reduce all the manganese from the charge, and bring it down into the regulus. This is caused principally by the silica which is present in the mix-

ture of ores or in contact with them during the operation. The affinity of the oxide of manganese for silica is so great that the reduction is almost entirely stopped so long as there is any free silica in contact with the manganese ore. The product of the combination is a liquid slag of a characteristic pale green color, and which contains a very high per centage of manganese. The metal entering into this combination is, therefore, altogether lost for the metallic regulus, and only a part of it can be recovered by a subsequent utilization of these slags in other processes.

With proper selection of materials the average proportion of the alloy obtained by this process is from 20 to 30 per cent. of manganese. A furnace of ordinary dimensions, and worked by one man, will produce about 15 cwt. of ferro-manganese every 24 hours. The principal element of expenditure is the cost of the carbonate of manganese, which is subject to considerable fluctuations. At the maximum quotation which this substance now commands in the market, the cost of manufacturing 1 ton of the ferro-manganese of 20 to 25 per cent. is about £7, independent of royalties; but with improved experience, and by the further development of this process, the expenditure may in all probability be reduced very considerably in future. The value of a rich alloy of manganese to the steel manufacturer is very great. For the manufacture of the softest kinds of steel, an alloy containing 15 or 20 per cent. manganese has, at one time, been considered an indispensable addition by many of our leading metallurgists. For this reason, the price which steel makers used to pay for this alloy was very high. The rule laid down originally by Mr. Bessemer himself was to rate the ferro-manganese at £1 per ton for every unit of manganese it contained. By this rate the value of the 25 per cent. metal would reach £25 per ton. Commercial experience has, in the course of events, decided against this somewhat arbitrary mode of calculation; and the standard which is now put upon the value of ferro-manganese is taken from the actual price of Prussian spiegeleisen, and compared with the price of a mixture of ordinary hematite pig, with that quantity of ferro-manganese which will bring the mass up to the same percentage of manganese as that held by the spiegel. Taking, for instance, the price of spiegeleisen which averages 7 per cent. manganese, at £7, the equivalent mixture of hematite iron and ferro-manganese of 21 per cent. will be made up as follows:—

Two tons hematite iron, taken at £4.........	£8
One ton ferro-manganese, at.	13
Gives three tons of metal, of seven per cent..	£21

It appears, therefore, that the commercial value of a 21 per cent. ferro-manganese, under ordinary circumstances in this country, must be taken at £13 per ton as a minimum. It appears equally obvious that the manufacture of these artificial alloys will be a suitable and remunerative industry, and will form a useful accessory to every Bessemer steel works in this country. The steel makers will obtain a better and more regular supply of spiegel, and will make their works independent from all accidental fluctuations and inconveniences of the spiegeleisen trade, such as now exist between this country and the Liegen district.

The St. Louis "Journal of Commerce" states that during the coming season the Vulcan Iron Works Company of South St. Louis contemplate erecting a blast furnace that will surpass in size anything of the kind in the United States. The new furnace will stand on 12 columns, each 13 ft. in height; will be 25 ft. interior diameter, or bosh, and 100 ft. high. It will have 5 times the cubical area of any furnace now in Carondelet. The blast will be propelled by 2 powerful engines. Her hot blast will be entirely of fire-brick, encased in wrought iron, and it is expected that a heat of from 1,400 deg. to 1,600 deg. will be obtained. The company already have 2 furnaces, one of which has been in blast since the 14th of November last, during which period it has yielded between 5,000 and 6,000 tons of pig iron, and is now turning out from 48 to 50 tons per day. Furnace No. 2 will be put in blast immediately.

The largest rope in the world has been completed in Birmingham, England, and is about 6 miles long, $5\frac{1}{4}$ in. in circumference, and weighs over 60 tons.

THE BIG GUN OF WOOLWICH.

From "Nature."

Whether considered as a weapon of terrible power or simply as a specimen of skilful and successful forging, the 35-ton Fraser cannon is without parallel. Of extraordinary strength and proportions, and withal so carefully, and, one might almost say, elegantly finished, this magnificent gun is indeed a masterpiece well worthy of the greatest factory in England, from which it emanates. Cannon of larger dimensions have, it is true, been produced capable actually of delivering a heavier projectile than that employed with the Woolwich weapon, but none of them are to be in any way compared with this, either in respect to battering power or length of range. That the gun is, moreover, not merely a show production, as was the case with the monster Krupp cannon, but a really serviceable and efficient fire-arm, is shown by its endurance of the severe test to which it was subjected at proof. On this occasion the 700-lb. projectile was thrown from the gun by the enormous charge of 130 lbs. of gunpowder—the largest, in fact, that has ever been safely consumed in any fire-arm—the explosion being without the slightest injurious effect upon the steel bore or surrounding wrought-iron castings. The solid cylinder of iron which constituted the shot, issued forth at the terrible velocity of 1,370 ft. per second, and, after travelling some 50 yards, buried itself in the butt of loose earth to a depth of 33 ft.

The pressure of the gas at the time of explosion was, as may be supposed, exceedingly great, and herein obviously lies the great difficulty to be overcome in the construction of large guns; this pressure or strain, we find, increases in a much greater ratio than the amount of powder that is burnt would appear at first sight to justify, and for this reason large guns require to be proportionately much stronger than little ones. Thus, in the present instance, when a charge of but 75 lbs. of powder was fired, the pressure of the gas upon the copper piston at the rear of the projectile was shown to be 17 tons per sq. in., while 130 lbs. of powder (not double the former charge therefore) gave a pressure amounting to 64 tons on the sq. in. It has, by the way, been questioned whether this method of estimating the pressure by means, namely, of a copper piston which is pushed in upon itself, affords a strictly reliable test, but in any case there can be no doubt that the strain upon the gun is increased in a greatly increasing ratio to the quantity of powder consumed. When we state, therefore, that the weapon withstood in every part this excessive strain, and that, under ordinary circumstances, the cartridge will contain but 90 lbs. of powder, there is every reason to believe in the solidity and perfection of the structure.

The data obtained by the firing of the gun at proof, lead us to hope for very successful results from its employment. It is calculated that at a distance of 50 yards the heavy projectile would be thundered forth with such force as to penetrate 14½ in. of solid iron, an armor plate such as no vessels of our present construction are enabled to carry. At 2,000 yards—at upwards of a mile, therefore—the shot would possess enough penetrating force to pass clean through the side of the strongest iron-clad afloat—those of the Hercules class—or, in other words, is endowed with impact sufficient to pierce 12 in. of iron; and it must be remembered that this last-named distance is one at which gunners can make very good practice, so that, under ordinary circumstances, every other shot would take effect against a target such as is presented by the keel of a large frigate. As regards extreme length of range, a quality of some importance, when, as in the recent instance of the Paris siege, great projecting power is of more importance than precision of aim, this Fraser gun may vie with almost any other, with the exception, perhaps, of Whitworth's cannon. The utmost distance to which the "Woolwich infant," as it has been nicknamed, will in all probability be capable of projecting a shell is about 10,000 yards, supposing the arm to be laid at an elevation of some 33 deg.

So satisfactory, indeed, has this experimental structure turned out, that a further batch of sister guns have forthwith been commenced, and will serve to arm some of our heavy iron-clads which are now building. Only a small number of

such weapons will be carried by these vessels—2, or at the most, 4 apiece—and thus our modern men-of-war will present a perfect contrast to those of a dozen years ago, when a ship, being regarded merely as a box of guns, sometimes received on board as many as 130 cannon. Nevertheless, a broadside delivered from 4 guns of these giant dimensions (for the whole armament being carried in turrets, may be brought to bear at one time), representing almost a ton and a half of metal, very far exceeds that which an old first-class three-decker could throw into her antagonist, and would indeed be sufficient to sink most vessels at a first discharge.

As regards the method of building up these large guns, we need say nothing, seeing that the subject was fully discussed recently in these columns. It may be of interest to know, however, that in the present instance, as much as 50 tons of metal were employed in constructing the arm, and that at one time 30 tons of this was brought to a glowing white heat for the purpose of welding. The reverberatory furnace in which this massive coil was heated is an apartment in which a dozen persons could dine comfortably, and the length of the bars before coiling amounted to upwards of 1,200 ft. The length of the arm is $16\frac{1}{4}$ ft., and its extreme diameter 56 in.

IRON AND STEEL NOTES.

The Iron Trade in England.—There is no change of any importance to report in prices from the North of England, but the daily change in increased efforts to stimulate production is very apparent. This is an evidence of present prosperity, and an indication of the view which those engaged in the trade take of the future. Fresh iron mines are being opened up, fresh furnaces are in course of erection, fresh companies are in process of formation, the one object of all being to develop the resources of the district to the utmost possible extent. In the meantime shipments to the Baltic and various Continental ports are going on with increased rapidity, and masters are busy with the completion of orders already in hand. Fresh contracts are not made with such rapidity as, in consideration of the facilities of production, might be desired; but it is generally thought that the present lull will be succeeded by an influx of orders, which from one cause or another have been held back hitherto. Prices are—for No. 1, 51s.; No.3, 47s. to 47s. 6d.; No. 4, 46s. to 46s. 6d., net. American orders continue in a great degree to support the market. In the North, the United States, and the New York district especially, are large buyers, and in the South the Brazilians have supplied extensive orders. Canada, too, is in the market not only for rails, but for iron for bridge buildings. The exports from Wales during April were—Cardiff, 23,214 tons; Newport, 9,736 tons; Swansea, 2,856 tons=35,806 tons. The market is very firm, and as the general impression gains ground that higher rather than lower prices will rule, buyers are more desirous to pass contracts at current quotations. At the same time large orders do not come in with that rapidity which has been looked for. The make of pigs is stimulated in this district as in the North, and shipments are large. Swedish iron has met with purchasers of Indian assortment at £10 to £10 5s., ex ship. There has been a considerable amount of business transacted in Scotch pigs, and prices have advanced to 57s., the market at the close being rather easier.—*Bulletin of the American Iron and Steel Association.*

Microscopic Character of Iron and Steel.—According to Mr. Schott, the different qualities of iron and steel can readily be distinguished by means of the microscope. Thus the crystals of iron are double pyramids, in which the proportion of axes to the bases varies with the quality of the iron. The smallness of the crystals and the height of the pyramids composing each element, are in proportion to the quality and density of the metal, which are seen also in the fineness of the surface. As the proportion of carbon diminishes in the steel, the pyramids have so much the less height.

In pig iron, and the lower qualities of hard steel, the crystals approach more closely the cubic form. Forged iron has its pyramids flattened and reduced to superposed parallel leaves, whose structure constitutes what is called the nerve of the steel. The best quality of steel has all its crystals disposed to parallel lines, each crystal filling the interstices between the angles of those adjoining. These crystals have their axes in the direction of the percussion they undergo in the working. Practically, good steel examined under the microscope has the appearance of large groups of beautiful crystals, similar to points of needles, all parallel and disposed in the same direction.

It is rather singular, that while many journalists appear to have a proper appreciation of the advantages of a diversification of industry, and depict with force and clearness the value of prosperous manufacturing establishments to any section of country, they will, at the same time, advocate a policy that would not only prevent the growth of our great industries, but would inevitably result in the retrogression and decay of such as we have. The St. Louis "Republican" urges the fact upon the attention of its readers, that that city might, in the course of a few years, become the Sheffield of America, if enough capital and enterprise were applied to the development of its superior facilities for the manufacture of steel ware. It shows that in the Shepherd Mountain district, within a few miles of the city, there are exhaustless quantities of ore of the choicest quality for making steel. Well does the "Republican" know, that leaving out Bessemer steel rails, nearly one-half of the quantity of steel consumed in this country comes from abroad, and that this is not owing to the inability of our steel-makers to produce steel of the best quality, for all purposes, or to the incapacity of our people to make all that our country requires, but to the inadequacy of the tariff, or perhaps it would be better to say, to the impunity

with which it is evaded. The "Republican" further urges the establishment of rolling mills for the manufacture of rails in the neighborhood of St. Louis. Now we also believe that Missouri possesses all the resources that are requisite to make it the "black country" of America; but in the present condition of the rail manufacture the promise is not great enough to encourage "the liberal investment of capital" in that direction. A cargo of English rails, 30 lbs. to the yard, have recently arrived at New Orleans, which cost delivered there, all expenses paid, something less than $62, currency, per ton. The total consumption of rails in 1870 in this country was a little over a million of tons; of this quantity 472,403 net tons were imported, and, judging by the importations thus far, the quantity this year will be over 500,000 tons, or enough to keep 20 or 30 large rail mills in full operation. Place these rail mills in Missouri and other Western States, with tens of thousands of workmen necessary to operate them. and the advantages, which are now only sighed for in dreams, will be realized.—*Bulletin of the American Iron and Steel Association.*

Durability and Deterioration of Iron.—The late eminent engineer, Mr. J. A. Roebling, maintained that a good car axle made of good material and finished by the proper heat, by hammering or rolling, is stiffer and stronger than the same axle when again subjected to annealing without hammering or rolling; for, as annealing restores softness, but at the same time reduces cohesion and elasticity, to restore the iron of a brittle car axle fully can only be done by a full heat, with hammering or rolling, which of course reduces its diameter. The opinion, too, that a well drawn out fibre is the only sure sign of tensile strength, is true only when applied to ordinary qualities of bar or rail iron, the case being different with good charcoal irons and with steel. The greatest cohesion is accompanied by a fine, close-grained, uniform appearance of texture, which, under a magnifying glass, exhibits fibre, the color being a silvery lustre, free from dark specks. The finer and more close-grained the texture, the nearer the iron approaches to steel. Wire cables, car axles, piston rods, connecting rods, and all such pieces of machinery which are exposed to great tension as well as torsion and vibration, should be manufactured of iron which not only possesses great cohesion, but also a high degree of hardness and elasticity. The best car axles are those made of soft steel, by Krupp, in Germany, the steel being manufactured from the spathic ore, or natural steel ore, of the celebrated mines at Muessen in Siegen, Prussia. They are considered the safest in cold weather—one of the most important and valuable of qualities—and are seldom known to break.—*Iron Age.*

Hoop Iron Chains.—A chain of the most remarkable texture and workmanship is described in the English journals. The links of this chain, oval in shape, are made from ordinary hoop iron, galvanized and brazed. According to the accounts we have seen of this curious piece of work, the hoop iron is first wound on a reel by a machine suitable for the purpose until the requisite thickness is secured, after which it is passed through a furnace of molten metal. It is then rounded off and finished ready for the brazing, which completes the process. The links are then joined, and between each link is a stay, as in ordinary chains. The strengh of a chain thus made is said to be something enormous. In some experimental tests lately made, a 2-inch chain of this pattern was attached to a wrought-iron testing chain of $2\frac{1}{2}$ in. diameter, and on the application of hydraulic power the links of the hoop iron chain were elongated $\frac{1}{8}$ in., and those of the wrought-iron chain $\frac{5}{8}$ in.—the strain being equal to a suspended weight of 110 tons. When the strain had reached 114 tons the testing chain broke, and a careful examination of the hoop iron chain showed that, with the exception of some unimportant openings in the links, which did not seem to have been properly brazed, it did not show any evidence of the extraordinary strain to which it had been subjected. If the results thus described were actually reached, the invention may prove of the greatest practical importance as applicable to the manufacture of chains of unusual strength and small size. We have no information as to whether the process of manufacture is more expensive than that now employed, or whether it is less so—but if the information we have received respecting the strength of these chains be correct, we should say that any increase in cost would be more than compensated by the superior advantages of hoop iron chains for heavy work.—*Iron Age.*

RAILWAY NOTES.

Railroads Developing our Resources.—The effect of railroads upon the development of the resources of the country, and particularly upon the mineral wealth, was never more forcibly apparent than in the production of iron in new regions. Since the first road across the continent was finished, discoveries of both coal and iron ore along the whole route have been made. The Union Pacific Company now smelts its iron ores with its own coal, and proposes to erect furnaces, rolling mills and foundries to supply all its rails, wheels, castings, and other requirements, and this hundreds of miles west of the Missouri river. The North Pacific Railway Company have an abundant supply of ores and fuel upon their line, and have determined to make from these a great part of the rails they will use on that road. Last comes the Southern Pacific, which passes through a country on a portion of the line known to be rich in iron ores. The distance from the manufacturing centres would naturally render the delivery of rails on this line very expensive. But the road develops the supply of its necessities again in this case. A party of capitalists from Pennsylvania, seeing the market before them, have purchased a large tract of land in Alabama containing immense quantities of iron. They are preparing to erect the necessary furnaces and rolling mills, and already offer to supply the Southern Pacific Railroad with all the metal to iron its tracks, and for the construction of wheels, spikes, fish bars, etc., which may be required, for $10 per ton less than they can be furnished from Europe, or any other point in America. Here is direct evidence of the benefits of wilderness railroads, as they are termed, in opening up mineral resources, which, under other circumstances, would remain hidden for years. The road not only brings a population to the soil for its cultivation and agricultural development, but creates industries which

furnish at once a market for its products, and facilities for transporting the surplus to more distant regions. This is the true theory of development for the great area of unsettled lands, and no wiser policy can obtain with the companies now engaged in the construction of the trans-continental lines, and in the projection of lateral branches, than the manufacture of all the articles which enter into the construction of their roads, locomotives, cars and shops. By this means the country along the line will be rapidly settled, and an immense impetus given to the industry of the country, while the laboring classes will be also directly benefited.—*Iron Age.*

There is a rather interesting official paper in the last "Gazette of India,' showing all the accidents and injuries to life and limb that have occurred on the 4,581 miles of Indian railway during the past and previous years. Last year there were 69 collisions and 258 cases of running off the line. The collisions do not appear to have been of a very serious nature, the total number of accidents resulting from them being 3 persons killed and 42 injured, 1 death and 30 injuries having been caused by one accident alone. Of the total of these two classes of accidents, or 327, only 16 occurred on the East Indian Railway, while the great Peninsular line, with less train mileage, is credited with 228. The little Punjaub and Delhi line, of 541 miles, is stated to keep up its character as the worst managed line in India—to be improving on it, indeed—the preventable accidents last year being 51 as against 15 in 1869. Of 53 cases of fire, 38 occurred on the Punjaub line ; and of 314 cases of running over cattle, 128 were on the East Indian line. On the Bombay and Baroda line a half-grown buffalo caused the death of 11 passengers and the injury of 7. The report explains that the "cattle" run over include camels, wild buffaloes, wild pigs, and several bears and wolves. The actual number of passengers killed in 1870 was 13, and injured 63, or 2.53 per million, by causes beyond their own control and 1.65 through their own misconduct or incaution, which is below the average of the past 8 years. The most curious return is that given of the deaths of passengers occurring in trains or stations. No less than 152 deaths were reported in 1869, and of the 114 reported in 1870, 63 occurred on the East Indian line ; 43 happening in the train, the remainder in the stations. Fever, dysentery, and sunstroke are the prevailing causes of death. Except in the case of sunstroke, of which 6 European passengers died in the exceptionally hot weather of 1869, these deaths do not appear to occur at any particular season.

A New Car Wheel.—A new car wheel under the patent of I. B. Tarr, is being manufactured at the Fairhaven (Mass.) Iron Works, and it is proposed to establish works especially for the production of the new wheel in that vicinity. The superiority claimed consists in greater strength, lightness, and smoothness of the tread. The process of manufacture is described to be substantially as follows: The melted iron after being poured into the mould, is subjected to a pressure of many tons by means of a hydraulic press. All the gases are thus driven off and the iron is rendered more compact, homogeneous, and free from air bubbles, besides being forced into every part of the mould. The wheel comes out perfect in form, and of uniform density and strength. This process, as applied to iron, is precisely similar to that mentioned by Bessemer in his address before the Iron and Steel Association of England, published in our columns some time since, as producing the happiest results in steel. It is, moreover, used elsewhere in this country for the production of particularly fine and sharp ornamental castings for door and other fixtures. Casting under pressure is not a novelty, although its application to car wheels may be, and is likely to prove advantageous to the product.

Another Line to the Pacific.—At the last session of Congress) the legislation necessary to the perfection of arrangements for the construction of another railroad to the Pacific by a southern route was consummated, and under it an informal organization of the Texas Pacific Railroad has taken place. Mr. Marshall O. Roberts, of New York, who subscribed for $111,000 of the Company's stock, was chosen president of the temporary organization, and it is understood that the executive management of the Company, when fully organized, will be confided to that gentleman. The route of the new road will be found, we doubt not, most desirable, and the cost of construction will be materially less than that of any of its competitors, General Fremont, who was present at the informal organization of the Company, is a subscriber to its stock in the amount of $500,000. It is intended, as we learn, to place the bonds of the Company in the market at an early day, work being commenced in the meantime with the funds realized from the stock subscriptions.

The Great Railroad Lease.—At the annual election of the stockholders of the Camden and Amboy Railroad and Delaware and Raritan Canal Companies, held in Trenton, N. J., the question at issue in the election of directors—7 in the Camden and Amboy and 9 in the Delaware and Raritan Canal—was that of leasing or not leasing the works of the United Companies. The directors elected stand 9 in favor and 7 against leasing. As our readers are aware, a lease of the united works had been proposed to the Pennsylvania Railroad Company, which had accepted it. Subsequently a new proposition was made by the Reading Railroad Company, which latter in general terms proposes to take the Delaware and Raritan Canal on a perpetual lease, paying $750,000 per annum, and increasing the amount $10,000 per year, until it shall reach $1,000,000 per annum, which sum is to be paid annually thereafter ; and in case these terms are not agreed to, to take all the property of the United Companies, representing $35,245,000 actual cost, to pay 10 per cent. dividends yearly and a bonus of $1,000,000. It has been stated in some of the city papers that the lease with the Pennsylvania Railroad Company had been settled definitely. This is a mistake. The proposed lease is still in the hands of the committee, not fully completed. It is understood that as soon as the terms are agreed upon, the lease will be referred to the stockholders for their approval, after at least 20 days' notice shall be given. We presume from the tenor of the offer of the Reading Railroad Company, that it would be satisfied with the lease of the Delaware and Raritan Canal to facilitate its coal shipments eastward.

There are 17 passenger street railway companies in Philadelphia, Pa.

ORDNANCE AND NAVAL NOTES.

The Italian Mercantile Marine.—The Italian Customs has recently published some tables showing the total number of vessels which have entered and left Italian ports. They were 233,697, with an aggregate tonnage of 17,979,591 tons. The vessels under the Italian flag were 213,580; and those under foreign flags were 18,882. The total number of the crews of these vessels was 518,930 men, or at the rate of 12 men for every vessel. British vessels entered inwards had a collective strength of 40,406 men, which was reduced to 35,564 men for the vessels leaving Italian ports. The crews of French vessels amounted to 56,467 men. The average number of men belonging to every French vessel was 25 ; to every Russian vessel was 17 ; to every British vessel was 15 ; to every Norwegian vessel was 12 ; to every Austrian vessel was 11 ; to every American vessel was 10 ; and to every Spanish, Greek, and German vessel was 9. The proportion per 1,000 tons was 87 men for Austrian vessels ; 77 for French ; 73 for Spanish ; 54 for Dutch; 52 for Greek ; 46 for British ; 40 for Russian ; 39 for German ; 34 for Norwegian ; and 26 for American. The coasting trade gave employment to 188,034 Italian vessels with an aggregate tonnage of 10,164,412 tons ; 1,404 French vessels of 337,480 tons ; 419 British vessels of 148,238 tons ; 65 Dutch vessels of 22,893 tons ; 187 Austrian vessels of 16,265 tons ; and 166 vessels of 20,802 tons, collectively under the Papal, Norwegian, German, Belgian, Spanish, Greek, Russian, Danish, Tunisian, Ottoman, Armenian, Swedish, and Portuguese flags. The numbers of passengers who left or entered Italian ports were 1,109,122 ; 65,427 persons went to and 64,387 arrived from foreign countries ; and 13,147 embarked for America.—*Mechanics' Magazine.*

Experiments at Shoeburyness.—Thursday was one of those show-days at Shoeburyness of which the object is to give the visitors as much as possible for their money. The entertainment is required to be of a piquant character. There must be a slice from every dish which Shoeburyness can serve up—a slice well spiced and seasoned, a slice which is beyond no one's powers of digestion. The plain fare of an ordinary working day will not do on a "special-train day." There must be a little 12 in. gun, and a little 9 in.; a *soupcon* of Moncrieff carriage, a flavor of field gun, a spice of segment, and a finish of shrapnel, some life-saving rocket, and a morsel of 7-pounder. The effect on the targets is less considered than the effect on the visitors ; and important contributions to the professional knowledge of our engineers and artillerymen are not often made on days like these. And yet such days are not wholly thrown away. They are occasions on which a large number of persons are for the first, and in many cases the only time of their lives brought face to face with the realities of actual practice. Probably no one who has not seen a stout iron target fired at has much idea of what it is like, or realizes the crowded concealment in the bombproof, the moment of expectancy, the earthquaking discharge, the quick patter around of the iron fragments, the run through the dense sulphurous smoke to the targets, the examination of the curious deep hole, the sides of which are too hot to be safely touched. There is a great deal in all this which is interesting, and even exciting, and it is certainly desirable that the interest of these experiments should find its way, beyond those who are professionally engaged in them, to the outer world. The vast importance of these experiments is such that we should be very sorry to see anything done which could in any way reduce such public sympathy and support as they now receive ; and, therefore, we should be very sorry to see these occasional gala days at Shoeburyness given up. Nevertheless, it is fair to observe that they are not days on which much real work is done ; and to this rule Thursday's experiments were no exception. The main business of the day consisted in practice against two targets, which represented turrets of vessels of the Thunderer, Devastation, Rupert, and Fury class. No. 34 target consisted of a solid 14 in. plate, resting on vertical (9 in.) and horizontal (6 in.) balks of teak backing, with an inner iron skin of $2\frac{5}{8}$ in. plates and the usual iron ribs. No. 35 target consisted of a solid 8 in. plate on vertical 9 in. teak balks, then a 6 in. plate, and then horizontal 6 in. teak balks, with the skin and ribs as in No. 34. Against these two targets were ranged at a distance of 200 yards the three most powerful guns in this country (if we except the single specimen of the 35-ton gun), viz., the 12 in. of 23 tons, the 11 in. of 23 tons, and the 10 in. of 18 tons. Only the first of these was fired on Thursday. One 12 in. Palliser shot and one 12 in. Palliser shell was fired at each target. The superiority of the cord shot to the shell against these very thick targets were fully established by these 4 shots. In both cases the shot penetrated to a considerable depth, while the shells burst apparently, before their penetrative power had been satisfactorily developed. Neither turret was penetrated ; the interior being, for all practical purposes, uninjured. The practice against these targets was continued on Friday with the 12 in. and 11 in. guns. On this occasion more injury was done. One shot from the 12 in. broke two bolt heads from No. 35 target, and illustrated the inferiority of those bolts with the *minus* thread and Bascombe washer to the well-tried Palliser bolts, which the Admiralty for some reason or another appear indisposed to adopt. An 11 in. shot struck at the junction of the two plates of No. 34 target, and wedged them open in such a way as to cause considerable damage to the turret ; and another round from the same gun made daylight through the same target by driving one of the large bolts before it into the interior. It is not possible to pronounce confidently from such limited data as to the relative powers of resistance of the two structures ; but the general impression appeared to be that No. 35 target (with the 8 in. and the 6 in. plate) had rather the best of it. This construction—the details of which, however, admit of considerable improvement—has the further merit of being less costly in the proportion of about 35 to 50. The experiments against these targets will be continued next week. The most interesting feature of the trial was the very satisfactory performance of the new pebble powder. The introduction of this powder has raised the 12 in. gun from a sort of monster howitzer of inferior penetrative capabilities into a plate-piercing gun or enormous power. With R. L. G. powder the initial velocity of the 12 in. shot was only 1,180 ft. per second. It is now 1,300 ft. per second, and the effect of this is that the force of the blow struck has been raised from 5,793 to 7,030 foot-tons —or, in other words, the penetrative power of this gun is now as great at 1,000 yards as it formerly

was at the muzzle. The 11 in. gun, although possessing the same power of penetration—measured in terms of the "energy' per inch of the shot's circumference—is in total power slightly inferior to the 12 in. as 6,415 is to 7,030. But on Friday the 11 in. was rather more lucky in its hits, and made rather a greater show. The increase of power of all our heavy rifled guns due to the introduction of pebble powder is very considerable. The velocities of the guns have, we understand, been increased as follows:—the 12 in. by 120 ft. per second; the 10 in. by 85 ft.: the 9 in. by 80 ft.; the 8 in. by 85 ft.; the 7 in. by 90 ft. To any one acquainted with the subject the force of these figures will be apparent. How in face of these results, coupled with the fact that these increments of velocity are obtained with actually less strain upon the gun, any one can be found seriously to argue against the speedy supply of pebble powder we are at loss to understand. *Habitués* of Shoeburyness at all events were able to appreciate the tangible evidence of the efficiency of pebble which was afforded by the magnificent, and we believe unparalleled penetrations which were obtained through its agency on Thursday and Friday. And if the impression which the *habitués* derived was conveyed to some of the illustrious visitors who were present, last week's experiments, if they teach nothing else, will not have been thrown away.—*Pall Mall Gazette.*

A French Soldier's Kit.—M. Grimaud de Caux has proposed to the Thiers government the introduction of a new kind of knapsack, half the thickness and double the length of the one now in use in the French army, and which the soldier might wear either on his back or on his breast. This modification offers some advantages even in battle. The man in this case has his knapsack before him; and when the fire of the artillery is silenced he may advance upon the enemy to a distance of 150 yards. Here he lets down the longitudinal blade which is contained in the knapsack, so as to make the latter rest upon it, thus making, instantaneously, a kind of breastwork, impenetrable to the bullet, and from behind which he may fire, supporting his musket upon it so as to have a sure aim. The enemy's bullets will mainly fall on the knapsack, or on a kind of metal shade with which M. Grimaud provides the soldier's kepi as a protection for the face. The projectiles will also be averted by the numerous folds of the tent canvas, which hangs like an apron from the bottom of the knapsack. After the battle, whether there be a victory or retreat, a camp has to be pitched. Under the present system, the *tentes-d' abri* are formed, occupying a very small space both in surface and altitude, and only allowing sleeping-room to the 4 men who have contributed their share to the tent. The cooking is done outside with a very precarious and smoky fire, the materials for which are not always at hand, and which cooks the victuals badly and slowly, especially when there is wind or rain. The whiteness of the tents, moreover, reveals to the enemy the place of the bivouac. M. Grimaud's plan does away with or greatly diminishes all these inconveniences. If the halt be only momentary, the new long knapsacks may in a few minutes be placed in rows, supporting each other, so as to form a shelter for 12 men. If the encampment is to last some time the metal shade will serve the soldiers for digging a fireplace, with its requisite gutters; meanwhile, the 12 knapsacks of the squad are placed upright and fixed, while the tent canvas is drawn over them so as to form a complete shelter. The kitchen fire is concealed from the enemy; the smoke is less intense, and swept away by the draught. M. Grimaud states that the first idea of this plan was conceived by the Polish General, Mieroslawski.

Messrs. John Elder & Co. recently launched from their shipbuilding yard at Fairfield, Govan, an iron screw steamship of 2,789 tons, B. M., and 600-horse power nominal, for the Royal Mail Steam Packet Company of London. The vessel has been designed and constructed for that Company's service between Great Britain and the West Indies, and is of the following dimensions: —Length over all, 358 ft.; breadth, 40 ft.; depth moulded, 35 ft. Her accommodation for passengers is of the most complete description. Besides providing comfortable accommodation for 75 second class, and 50 third class passengers, she is furnished with cabin and sleeping apartments in the highest style of elegance and comfort for 270 first-class passengers. This vessel is similar in construction to the Elbe, launched by the same firm 18 months ago, and which has proved so successful, and also to the Tagus, launched by the same firm in January last, and which left Greenock for Southampton on Thursday afternoon. As the ship left the ways she was gracefully named the Moselle by Miss Marshall, of London.—*Engineer.*

Iron-clad Building in the Golden Horn.—The "Levant Herald" says that on the 25th ult., the ceremony of lifting the sternpost of the Mukat-demiheigher, the first iron-clad—we may say, indeed, probably the first iron ship—laid down in Turkey, was successfully performed in the presence of the Minister of Marine, the members of the Admiralty Council, and a large company of other official spectators. This vessel is being built at Tershaneh, from drawings and specifications furnished by Mr. Reed (late Chief Constructor to the British Navy), and is sister ship to the Fati Bulend, built at the Thames Iron Works. Her dimensions are as follows: Length between perpendiculars, 235 ft.; breadth at water line, 38 ft.; breadth at battery, 42 ft.; tonnage (builder's measurement), 1,601; draught of water, mean (deep), 17 ft. 3 in.; engines, nominal, 500-horse power. The Mukat-demiheigher will be armed with 12½-ton Armstrong guns, enclosed in a central box or battery, which, as the dimensions show, projects out 2 ft. on each side, something like a bow window. This arrangement has enabled Mr. Reed to realize his favorite theory of "all round fire," with ample accommodation for working ropes, etc., which he maintains has never yet been satisfactorily realized in a turret vessel, though, perhaps, the nearest approach was the ill-fated "Captain," designed by Captain Coles. The thickness of the armor plates on the central box of the ship now building at Ainali-kavak, will be 9 in. and 6 in., supported by a backing of teak, 9 in. and 12 in., behind which is worked a "double skin," and a framing of very strong scantling. The armor belt beyond the "box" extends to a depth of 4 ft. below and 2 ft. above the water line, and will be of an average thickness of 5 in. The decks at the ends of the ship and over the battery, are entirely covered with iron plates, and a complete water-tight inner bottom is worked for nearly the whole

length of the ship. Besides which, she has the advantage of drawing no more than about 17 ft. water—some 6 or 8 ft. less than the frigates of the English Navy.

If any additional testimony is required in support of Mr. Brassey's proposal to subject the adjusters of compasses to an examination before allowing them to exercise their calling, we have it in the evidence of the captain of that splendid vessel, the Queen of the Thames, recently wrecked near the Cape of Good Hope. He states that, in his voyage out, the compasses were never correct for four-and-twenty hours together; that one would be pointing south, another west, and another north-east, and that although the ship was swung at Melbourne, and a card of deviations supplied to him, his daily observations showed it to be unreliable and totally at variance with the course made good. In this evidence he was confirmed generally by the chief officer and also by the second officer. Now, even while remembering that all iron-built ships are more or less liable to variations in their magnetism, it is difficult to understand such variations in the compasses as are here described, if they had been properly adjusted, more especially after the re-swinging of the ship at Melbourne, and one is forced to the conclusion that, in this, as in many other instances, the adjustment has been improperly made.—*Mechanics' Magazine.*

Holmes' Storm and Danger Signal Light.—Some practical experiments of great value have recently been tried at sea with this new light, with a view of testing its powers as applied to ships' signals. On the 5th of this month the steamship St. Magnus, when two miles off Aberdeen harbor, upon her voyage north, cast overboard at 11.15 P. M., one of the lights to illustrate the life-buoy service ; the effect of the light being viewed from Aberdeen pier. The intensity and steady burning of the flame produced upon contact with the water was most remarkable, illuminating the sea for a considerable distance around and burning upon the surface of the water with a brilliancy scarcely inferior to that of the lighthouse, as viewed from the deck of the steamer at some five or six miles distant. This light continued to burn for over an hour. At 11.20 P. M. a second signal light was exhibited from the after peak of the St. Magnus, and such was the power of the light thrown off that the captain of the Queen steamer reports, on passing the St. Magnus at a distance of two miles, the ship was almost invisible from the glare of light which surrounded her, and, being unaware of the nature of the experiment, at first feared she was on fire. The light from the peak of the St. Magnus was distinctly visible at a distance of over 13 nautical miles, and it continued burning until 3.50 A. M., more than three hours. Other experiments made with this new signal light during very stormy weather at Kirkwall, have been equally satisfactory, and go far to establish the value of the light for marine and signal purposes.—*Mechanics' Magazine.*

American Fire Arms in Europe.—The favor with which the improved patterns of American fire-arms regarded in Europe bids fair to give them the preference over all forms of rifles and muskets now in use in the armies of the great powers, not excepting the Chassepot and needle gun, the Sneider and the new English arm, the Martini-Henry. During the late European war we exported to France from this port not less than 600,000 muskets, but these shipments are of but trifling importance compared with the heavy orders which our manufacturers have received for the most approved patterns of rifles which have received the approval of the American government and were subjected to practical and satisfactory tests in the late civil war. Among the new American rifles, the Remington seems to be the most popular abroad as well as at home. The first European order for the Remington rifle was received some five years ago from Denmark, to which country 42,000 were shipped. Since then Sweden has taken 30,000; Cuba, 50,000; Egypt, 110,000 ; Rome, 10,000 ; Japan, 3,000 ; France, 150,000, and Greece, 30,000. The German government has not ventured the experiment as yet, but it is stated, on high military authority, that the needle gun is not entirely satisfactory, and that if the proposed re-armament of the German forces is carried into effect, the American arm will be given a chance to compete with those of European manufacture. Beside the Remingtons exported, we have sent abroad many thousand stands of old muskets, 200,000 Berdan rifles, and upwards of 60,000,000 cartridges. We have also sent abroad a considerable amount of ordnance, heavy and light. Altogether, our shipments of arms to Europe since the commencement of the late Continental war, are said to have reached the following enormous totals: 500,000 carbines and rifles, 20,000 revolvers, 214,247 Remington arms of various kinds, 300 Parrot guns, 36 Gattling batteries, and over 100,000,000 cartridges. Is is to be regretted that commerce in war material is not at an end forever, but while there exists a market for such goods, which must be supplied from some source, it is gratifying to our national pride to know that the skill of our inventors is recognized and appreciated abroad, and that American arms are considered superior to the best of those made elsewhere. The Old World cannot teach us much that is worth knowing about working in iron, whether the article to be made is a steamship, a bridge, or a repeating rifle.—*Iron Age.*

The Bonetta, another of the new class of gun-boats, has just been launched from Messrs. Rennie's shipbuilding yard at Greenwich; the sister boat, the Arrow, was completed a few weeks since. These boats will each carry one 18-ton gun, are built on the same principle as the Staunch, and are specially designed for coast and harbor defence.—*Mechanics' Magazine.*

ENGINEERING STRUCTURES.

The Great Bridge at St. Charles, Missouri.—Of this structure, just completed, we shall give a full description in our next number. The following brief statement of the dimensions of the work we received by favor of the chief engineer, C. Shaler Smith :

The St. Charles Bridge is composed of seven spans, varying from 306 to 321½ ft. in length, and 4,800 ft. of iron viaduct approach.

The piers are of masonry, and the depths of the foundations are respectively 76 ft., 73 ft., 71 ft., 68 ft., 54 ft., 23 ft., 7 ft., and 22½ ft. below water level. There are three spans over the mid river, 90 ft., above low water, and admitting of 900 ft. shift of channel.

The rise and fall of the river at this point is 40 ft., and the depth of scour, 43 ft.

During the progress of the work the river attempted to change its bed—cutting in over 1,400 ft. just above the bridge. The successful controlling of the Missouri river was probably the most difficult part of the undertaking.

An Indian Ship Canal.—The proposition to construct a ship canal, connecting the Gulf of Manaar with Palk's Strait, which has been so strongly urged by Sir John Elphinstone, has been brought under the notice of the Secretary of State for India, by a deputation from the East India Association, which was permitted to wait upon the the Duke of Argyll on Wednesday last.

The object of the work is to form a navigable channel between the mainland of the Indian Peninsula and the Island of Ceylon, and thereby to avoid the circumnavigation of the island, and some 360 miles distance. The conformation of the obstacles which now separate the Gulf of Manaar from Palk's Strait is extremely curious. On the north-west coast of Ceylon, and belonging to it, is the Island of Manaar, and from this there extends for a distance of 25 miles a line of rocks and shoals, to the Holy Island of Rameseram, on the Indian coast, and separated from it by about a mile of sea, strewn with sandstone boulders rising 8 ft. above the water level. A good many years ago, by removing some of these boulders, and blowing up others, a crooked channel was created, which was kept clear by the current running through the Palk's Strait, but which was totally unfit for general navigation.

Along the whole of the coast, from Tuticorin to the Island of Rameseram, the shore is lined by a row of small islets connected by sand-banks, on the other side of which the surf of the Gulf of Manaar breaks, and which landlock the channel lying between them and the mainland. The scheme of Sir John Elphinstone is to cut a canal through one of the sand-banks for a distance of 250 yards, giving access to a completely protected harbor 16 square miles in extent, and further to make a short ship canal across the Tonitory Point, a small promontory which stretches out toward Rameseram. This latter work would give direct access to Palk's Strait, and thence to the Bay of Bengal. The estimated cost for the work is £90,-000.

Another important advantage pointed out in connection with this project is the substitution of an excellent refuge, instead of the dangerous and exposed harbor of Galle. This harbor, beset with rocks, and open to the full swell of the Southern Ocean, is also insufficient for accomodation, and the difficulties and expense connected with improving it are so great, that the idea is for the present abandoned. But with the proposed canal, an ample roadstead would be provided in the Gulf of Manaar, on the direct route the ships would take on their way through the new channel.

The commercial prospects of this work are based upon the trade statistics of Calcutta and Madras, which at present amount to 2,000,000 tons a year. Of this about three-fourths would pass through the canal, in addition to some 200,000 tons of local coasting trade, so that there would be some 1,700,000 tons a year upon which to take toll. The tonnage rate proposed is 1½d., which would yield on the above amount about £10,000 a year. This may be an over-estimate, but the advantages to be derived from the improvement are so great as to make the matter of pecuniary success of secondary importance.

The work, which has so long been urged upon the Government, outside as well as within the House of Commons, has, in common with many other great Indian questions, been shelved, or, at least, received with the languid interest which characterizes most Indian debates, great or small. Now, however, that it is being more strenuously urged, and especially now that private enterprise is prepared to find capital to execute the work, there appears a reasonable chance of Sir John Elphinstone's efforts being crowned with success.

The New Pier System for New York.—General McClellan's report makes known the plan adopted by the Commission for the piers of our city.

As stated by the Commissioners, the main feature of the system now devised, is a wide river street, varying from 150 to 200 ft., and completely environing the water front. This will afford ample room for the movement of freight, and uninterrupted transportation by rail. Of course, due regard must be had for existing rights. For example, at Fulton Market, the lease of water front has ten years to run. But the fact is obvious that the new constructions may not even approach a completion while the present generation survives. All the new river front will be lined with a solid wall of masonry, probably granite, in combination with a concrete called Beton, which is composed of Portland cement and broken stone, and has the quality of hardening when immersed. The endurance of this substance has been fully tested in the harbors at Cherbourg and Algiers, also on the Suez Canal. This sea wall or bulkhead will cost, according to estimates, something like $2,500,000 per mile, and the depth of water alongside will be not less than 20 ft., sufficient to float the heaviest loaded merchantman. From the sea wall, projecting into the river, will be a series of piers, most of which will be of wood, of the most substantial character, but a limited number will be constructed of stone or iron. The piers will vary in length, according to the width and location of the channel—from 300 to 500 ft. long, and from 60 to 100 ft. wide, and will be built with iron columns, or stone, or wood, according to circumstances. The column at the head of the pier is of granite, its entire height, and extending the full width of the pier, in order to guard the structure from damage by concussion from vessels and heavy drift ice. The other columns are of iron, having an interior diameter of 6 ft., in order to give room for the men while they are at work inside sinking them to the bed rock. When in position they will be filled with rock and hydraulic cement, so as to form solid columns. There will be rows of three iron columns abreast, one on each side of the pier, and one in the middle, between them, supporting the trestle-work and flooring. Of course, if it is deemed necessary, solid stone columns can be used instead of the iron, or part granite and part Beton, as in the bulkhead. The bulkhead may also, if necessary, be made entirely of granite. The piers have been so arranged that the tide will act as fully as possible in carrying away the mud in the slips, and tend to decrease the cost of dredging them by machinery. The distances between the piers will be 200 ft. It is also intended

to cut the sewers through the stone bulkheads and extend them by large pipes under the piers to or near the pierheads so that they may not obstruct the ships with their deposits. Iron mooring piles will be placed on the piers for the accommodation of shipping lying alongside.

THE DETROIT TUNNEL.—The building of the great sub-fluvial tunnel under the Detroit river, the completion of which is now assured by the practical consolidation of the Michigan Central and Great Western Railroads, will be the greatest engineering work of its kind ever projected in this country, if not in the world. The lake tunnel at Chicago, though of considerable length, is of small capacity, and will bear no comparison with that to be built at Detroit, while those carried under the river at the former city, though of good size, are so short as to be in all respects inferior to the present undertaking as engineering works. In the magnitude of the plan of its construction, in the capacity it will have under water, and in the amount of business which will pass through it, the Detroit tunnel will certainly have no rival upon this continent until the long contemplated scheme of uniting New York with the New Jersey shore by a tunnel under the Hudson is carried into effect.

The plan finally adopted by the tunnel company for the construction of the great work is substantially the same as that prepared some months since by Mr. Chesbrough, of Chicago. The length from the Detroit to the Canada portal will be 8,568 ft. It will be built in two separate parts, with a view to diminishing the amount of excavation necessary, and lessening the liability to accident, and also for the important consideration that, if an accident should occur in one-half, the other would still be available for the passage of trains. The parallel tunnels will be cylindrical in form, and will be 50 ft. apart. The interior diameter of each is 18½ ft., and at all points under the river the shell of masonry will be 2 ft. in thickness. The excavation will be made through a stratum of hard clay, and it is not intended that it should at any point come within less than 20 ft. of the surface of the bed. Whenever it is found that the distance is less than this average, clay will be filled in to a sufficient depth to avoid the possibility of accident. In addition to the main tunnels a small drainage tunnel, with an interior diameter of 5 ft., will be built considerably below the main lines and midway between them. This will be first constructed, in order to drain the main tunnels while the work progresses, as well as afterwards, and also to fully develop the character of the soil at the commencement of the work. The grade of the transit tunnels is one in 50 at each end, with 1,000 ft. of level line under the river. The estimates for excavation and masonry are as follows :

	Cubic yards.
Excavation in open cutting.........	200,000
" " tunnels..............	233,000
Brick masonry (exclusive of drainage tunnel).........................	68,000
Stone masonry.....................	3,700

A working shaft, 10 ft. in interior diameter, will be sunk on each bank of the river midway between the main tunnels, and connected with them by lateral drifts, each with an interior diameter of 9 ft. It is estimated that, without sinking any working shafts in the river, the work can be completed within 2 years. The entire cost of the tunnel and approaches, including a permanent double track of steel rails, right of way at the ends, etc., will amount to $2,650,000. The work of constructing this important international tunnel will be undertaken by a company chartered by the Canadian Parliament under the name of the Detroit River Transit Company, and such action as is needed to secure incorporation under the laws of Michigan has already been taken. This Company is organized on a basis of $3,000,000 capital, and is authorized to issue stock and bonds, and to consolidate with any company organized for the same purpose under the laws of Michigan. The money for the undertaking will mostly be obtained abroad, either stock or bonds being placed in the English market, and funds obtained at a comparatively low rate of interest, not over 6 per cent. The two railways interested in its completion, the Michigan Central and Great Western of Canada, will probably guarantee the payment of interest on such stocks or securities as may be issued, and the advantage gained for the lines in doing away with the costly ferriage system now established, and in the increased certainty and speed of shipment across the river, will certainly more than repay the cost of the tunnel in a few years. The enterprise is one of great magnitude and importance, and its completion will mark the beginning of a new era in American railroad engineering.—*The Iron Age.*

THE NESQUEHOMING TUNNEL.—It is not generally known that a tunnel which, for scientific engineering, and economy, speed and durability of work, is not surpassed by the Mount Cenis or Hoosac tunnels, is being driven by the Lehigh Coal and Navigation Company, of Pennsylvania. The location of the tunnel is near Summit Hill, Pa., and it is being driven for the purpose of doing away with the Switchback railroad. It is a continuance of an old mining tunnel known as No. 7, and when completed will be nearly a mile in length. The Company adopted the location as the most central and desirable, and the old tunnel having been driven 1,500 ft. to the Mammoth Vein, made a considerable less distance to be cut. Although little known by the public, engineers of celebrity state that the science of tunneling is here illustrated under the most perfect conditions, and that the record of the work is eagerly examined by experts, both here and in Europe. The work, to describe the whole of which would require too much space, was at the beginning prosecuted by hand drilling, but as soon as the Burleigh drills were introduced, they were adopted after trial, and went into operation March, 1870, since which time they have given great satisfaction. The tunnel is driven through the coal measures, cutting each vein known in the region, and after passing through them, it penetrates an intensely hard conglomerate, leaving which, it enters red shale.

A brief description of the Burleigh drills used will be interesting. The drills are driven by condensed air, which is pumped by six 20-horse power steam engines into a large iron receiving tank, from which it is conducted into the tunnel through a 6-in. pipe of cast iron, and is distributed by hose to the 3 carriages which support the drills. These 3 carriages support the drills used for the heading and the first and second

enlargements. The heading carriage supports 5 drills, the first and second enlargements each having 3. Motion is given to the drills by the action of condensed air in the cylinder, the piston of which is connected directly with the drill. Their working is far superior to that of any previous process, a 3-in. hole having been driven in sandstone in 11 min., while the average progress in the hard conglomerate rock is 7 ft. per hour. The heading is now in the red shale, and is proceeding at the rate of 35 ft. per week.

Work is soon to be prosecuted from both ends of the tunnel, and the boiler and blowing engines are erected and in readiness at the north portal. When under full headway, about 60 ft. per week will be made, and at that rate the two headings will meet in September. The enlargements follow upon the heading, and it is expected that trains will run through by January, 1872. The work, when completed, will save great expense and delay in moving trains on the Lehigh Navigation Co.'s roads, and will be quite as much an object of curiosity to tourists as was the famous Switchback railroad, which has been visited by many thousands.—*Iron Age.*

NEW BOOKS.

Reports of the U. S. Commissioners to the Paris Exposition of 1867.

These reports are now gathered into a collection, forming a set of six octavo volumes bound uniformly. The editing of the whole has been in charge of Mr. Wm. P. Blake, the commissioner from California.

It is rare that Government reports contain so much that is valuable to science, as is collected in these volumes.

Fragments of Science for Unscientific People: A Series of Essays, Lectures, and Reviews. By John Tyndall, LL.D., F.R.S. (Longmans, 1871). For sale by Van Nostrand.

Professor Tyndall has been well-advised by his American friends to give the world a companion volume to Huxley's admirable "Lay Sermons." The only fault we can find is with the expression that these Fragments are for unscientific people, which neither their history nor character justify. Here we have lectures delivered in the Senate House at Cambridge, before the British Association, and contributions to philosophical periodicals, embracing discussions on Miracles, Materialism, the Constitution of Nature, etc., and, so far from being suitable for unscientific people, we think any reader may take it as a fair test of the question whether or not he is a scientific person, that he fully comprehends the meaning and scope of these Fragments.

The volume contains fourteen papers, the best things that Dr. Tyndall has spoken and written in the last ten years; and, as all of them have been published already in some form or other, and have attracted much public notice, it is our duty merely to welcome their conjoint appearance in a volume that may be read over and over again with increasing delight by all who are, or are capable of becoming, "Scientific People." Though professedly "detached fragments," these essays and discourses form a very harmonious—we had almost said complete—system of physical philosophy. Some of the papers, such as the well-known ones on "Radiation" and "Dust and Disease," are of intrinsic scientific value, while others are of high speculative interest. We know no writings where larger or juster ideas are embodied regarding the processes of Nature, or the laws of energy, whether as affecting the stellar systems, or the ultimate material atoms.

Current Fallacies on Naval Architecture. By E. Gardiner Fishbourne, C.B., Rear-Admiral, R.N. London: E. and F. N. Spon, 48 Charing Cross.

This treatise, though only extending to twenty pages, is at the present time, when the Admiralty appear to be "at sea" respecting the stability of our iron-clads, very opportune. Coming as it does from the pen of one who is not only a naval officer of great experience, but who has also been deservedly considered one of the first authorities upon naval architecture, it especially recommends itself to the careful perusal of all who are interested in this important question. It is to a certain extent a sequel to the author's treatise on the loss of the Captain, which was noticed in "The Artizan" a few months ago. In the present work Admiral Fishbourne gives, by the aid of diagrams, a simple exposition of the various points there treated upon, together with an explanation of the scientific terms used, so as to bring the treatise within the comprehension of a non-professional reader. A perusal of this pamphlet, will, we feel confident, be not without advantage, both to professional and non-professional men, who are interested in the future of our navy.—*The Artizan.*

The Theory of Gunnery. By P. Anstruther, Major-General. London: E. and F. N. Spon, 48 Charing Cross.

This is a short brochure addressed to the Institution of Civil Engineers, and calling in question the correctness of the various mathematical works and manuals at present used as guide-books in the Government military schools. The author appears to desire that scientific men, free from prejudice, should test the accuracy of his conclusions, and therefore appeals from the military to the civil engineer. Thus in paragraph 21 he says:—"We are obliged to appeal to the civil engineers, because the military engineers have not the means, the artillery have not the will, to try the experiments required." This is, no doubt, complimentary to civil engineers, but we doubt if many, even if any, gentlemen belonging to that body could afford not only the means, but the time required to carry out experiments such as the author desires. —*The Artizan.*

Elementary Principles of Carpentry. By Thomas Tredgold. Revised from the original edition and partly re-written by John Thomas Hurst. London: E. and F. N. Spon, 48 Charing Cross. For sale by Van Nostrand.

We gladly welcome a new edition of this favorite standard work. Since the last edition, as our readers are no doubt aware, vast strides have been made, both in the knowledge of the best methods of construction of large works, and also in the discovery of new species of timber, some of which are peculiarly adapted for special purposes. Thus as regards bridges, the Americans have employed timber for their construction to a very large extent, in consequence of the cheapness of the ma-

terial, and in their endeavor to attain this object they have given us some very fine new examples of the principles of carpentry. Then, again, our knowledge of the varieties of timber has been very much enhanced by the excellent specimens forwarded to the various international exhibitions from our colonies and other parts of the world, where but little was heretofore known of their qualities. We have, we fear, yet to find timber thoroughly suitable for piles or sleepers in tropical climates, but much has been done, especially with the assistance of artificial preservation to ameliorate the excessive destruction, to which earlier works constructed with improper materials were liable. Upon the subject of timber, the present edition contains a great deal of valuable information, which, we consider, will be especially valuable to engineers engaged abroad.

Tables for Calculating Excavation and Embankment of Regular and Irregular Cross Sections. By E. C. Rice, C. E. St. Louis: R. P. Studley & Co. For sale by Van Nostrand.

All engineers whose labors involve earthwork calculations know the value of good tables. The set before us was evidently devised by one who has learned through experience what was most to be desired. The tables cover all the cases of ordinary practice, and are mechanically so constructed as to save the eyes and the patience of him who must use them. Each table is printed on a single page 9½ by 13 in., and in type of good size.

This merit does not belong to most of the tables with which we are familiar.

Mr. Rice has prefaced his book with an elucidation of his plan, and at the same time a proof that it is based on the "Prismoidal formula."

A Report on the Bridges across the Ohio River.

This is a pamphlet of 74 pages, containing a report of three engineers, Gen. Warren, Gen. Weitzel, and Col. Merrill, made by order of Government, upon the bridges of the Ohio River. The object was to determine whether the present or proposed structures were likely to interfere with the free and safe navigation of the river.

The minute details of the various measurements, and observations upon currents and their effects, are not only interesting, but afford highly instructive reading.

Instructions for the Management of Harvey's Sea Torpedo. London: E. and F. N. Spon, 1871. For sale by Van Nostrand.

The recent trials with Harvey's sea torpedo gave undoubtedly some very promising results, which will probably warrant the introduction of the weapon into the service to some extent. The book of instructions published by Captain Harvey, or under his direction, must be regarded, however, as somewhat anticipatory, especially that part of it devoted to the management of the torpedo vessel, and the dangerous weapon it directs. The hand-book comprises a very full description of the torpedo, with numerous drawings, showing its construction in every detail, together with particulars of loading it, and instructions for its management. With equal minuteness is described the method of handling it after it has been committed to the deep, and laid on the trail of a fated vessel. Captain Harvey considers that the torpedo ship best suited for the purpose is a vessel of about 400 tons burden, and 150 ft. in length, and built so as to insure the greatest possible speed, which is one of the leading requirements for such a service. With a vessel like the one he describes, Captain Harvey considers that he could manœuvre at his pleasure about a hostile fleet, threading his way between unfriendly vessels, and exploding torpedoes with fatal effects beneath them, now closing up right alongside, now taking as wide a berth as possible, that is to say, some 40 or 50 fathoms, according to the length of the rope. Of course darkness would, whenever practicable, be taken advantage of, for these hostile demonstrations, and it is stated on the strength of blockade running experience, gained during the American war, that comparatively little risk would attend such an operation. For our part, we differ entirely in this opinion, and we do not consider it possible for a vessel of the size and outline recommended for this torpedo service to manœuvre unseen close by an enemy's ship, no matter how great might be the darkness; and it is certain that the service would be one of the most dangerous connected with marine warfare. Not that such vessels would ever want for hands; during the American war there were always enough to be found as volunteers for those marine forlorn hopes, from which so few ever returned. There was but small chance, indeed; for those who luckily escaped the explosion were exposed to drowning, or the hail of fire, for which the torpedo explosion was a signal. The danger in such a boat as Capt. Harvey proposes, would probably be less than in one of the small nearly submerged craft, which carried the torpedo on the end of a spar, and ploughed its way slowly through the water by the efforts of the crew, who worked some mechanical contrivance for propulsion, until the object of attack was reached, and the collision occurred.

Nevertheless, in looking over the illustrations that accompany the "Tactics," one is struck with the quiet indifference of the threatened ships, which we are led to imagine would permit a hostile vessel, half their own size to approach within easy rifle range without sending her to the bottom. If it was stated that such an operation was attended with equal chances of destruction to destroyer and destroyed, we could understand it; but, on the contrary, it is hinted that the service would not be an exceptionally dangerous one.

These same illustrations, executed by Messrs. Kell Brothers, are excellent sketches in lithography, especially the last one, which represents the annihilation of a whole fleet of armor-clads by a number of torpedo ships, which deal death and destruction around, and apparently with as much security as if they "had the receipt of fern-seed, and walked invisible." If this picture were only historical instead of anticipatory, how interesting it would be!

The publishers have spared no pains in the style of finish of Capt. Harvey's book, which is, indeed, of interest and of value; but it is a pity that it is so carelessly and crudely written.—*Engineering.*

A Manual of the Principles and Practice of Road Making. By W. M. Gillespie, LL. D., C. E. Tenth edition, with large Addenda by Cady Staley, A. M., C. E. A. S. Barnes & Co., New York. For sale by Van Nostrand.

Gillespie's Roads and Rialroads is the title by which this excellent work has been long known to

engineers and surveyors, and its merits are so well understood that no lengthy comment can be of any special use. It is sufficient to say that no other work that we are acquainted with answers the same purpose.

The author, besides his peculiar qualifications as an engineer, possessed also those of an able instructor, and was thus doubly prepared for the task of writing on a subject of which even the technical schools teach almost nothing, but of which the learners are very numerous.

The Addenda which appear in the present volume, are prepared by a careful hand from the notes of the late author.

They relate chiefly to measurements of earthwork, railway curves, and bridges. On the first two of these subjects the treatment is of the clearest possible kind, and as complete as in the best treatises on these subjects.

In bridge building the wants of the common road builder have only been regarded, but the same concise method of statement characterizes the section.

Some brief articles on tunnels, grades, and methods of drawing specifications, will prove valuable to some of the many classes of readers that are certain to require and consult the book.

LIVES AND WORKS OF CIVIL AND MILITARY ENGINEERS OF AMERICA. By CHARLES B. STUART, C. E. New York: D. Van Nostrand.

This work possesses a twofold value for American readers. First, inasmuch as it affords a correct, though concise, account of the personal labors of the men who have become identified with the great engineering achievements in this country; and, secondly, in the history of the works themselves.

We are attaining a high rank as an engineering people. In some fields of labor our recent exploits have surpassed all that has been heretofore accomplished. How we have progressed from small to great, the history of our great improvements tells us. To whom we are largely indebted for the high and growing reputation of American engineering, Mr. Stuart tells us in his biographies.

How well both departments of the history are treated, the present number of the MAGAZINE bears testimony in the sketch of Benjamin H. Latrobe.

The work is handsomely printed on tinted paper, and embellished with steel engraved portraits.

The names of the engineers forming subjects for the present volume are Major Andrew Ellicott, James Geddes, Benjamin Wright, Canvass White, David Stanhope Bates, Nathan S. Roberts, Gridley Bryant, Gen. Joseph G. Swift, Jesse L. Williams, Col. William McRee, Samuel H. Kneas, Capt. John Childe, Frederick Harbach, Major David Bates Douglas, Jonathan Knight, Benjamin H. Latrobe, Col. Charles Ellet, Jr., Samuel Forrer, William Stuart Watson, and John A. Roebling.

An Appendix contains a description of the Union Canal, in Pennsylvania, in 1830, and the First Eight-wheel Locomotive.

MISCELLANEOUS.

A COMPARISON of the temperature and quantity of rain in the spring months for the 10 years previous to 1871, and also a summary for the spring of 1871, in the city of New York, by Oran W. Morris.

Year.	Mean Temperature.	Quantity of Water.
1861	49.46°	17.43 in.
1862	49.09	10.52 "
1863	49.13	16.04 "
1864	51.90	10.66 "
1865	54.39	18.02 "
1866	49.61	10.83 "
1867	45.29	12.26 "
1868	44.97	17.30 "
1869	43.99	13.16 "
1870	50.12	12.92 "
Mean	48.79°	13.91 "
1871	53.21°	13.95 "

The spring of 1871 was 4.42 deg. warmer, and 0.04 in. more water fell than the average for the 10 springs before.

The warmest spring was in 1865; which was 5.6 deg. warmer than the average. Spring of this year (1871) was 4.42 deg. warmer; a difference of 1.18 deg. between the extremes.

The coldest spring was in 1869, which was 4.8 deg. colder than the average, and 9.22 deg. colder than that of 1871.

The greatest quantity of rain fell in 1865, and the least in 1862; a difference of 7.5 in., and 4.11 in. more than the average.

The warmest day in the series, including 1871, was on the 30th day of May, 1871, 81.73 deg.; the coldest was the 3d day of March, 1868, 6.26 deg.

The warmest day in March was the 3d, in 1861, 62.53 deg.; in April the 22d, in 1866, 73.06 deg.; in May the 30th, in 1871, 81.83 deg. The coldest day in March was the 3d, in 1868, 6.26 deg; in April the 5th, in 1868, 28.06 deg; in May the 16th, in 1871, 38.40.

The highest degree of the mercury in the thermometer was 89 deg. at 3 P. M. of the 30th of May, 1871.

The observations noted above were made at 7 A. M., 2 P. M., and 9 P. M., on the same instruments, the thermometer in the shade, and a free circulation of air, and the readings of the barometer are reduced to 32 deg. Fahrenheit.

The spring of 1871 had the mean of the barometer, 29.843 in.; the maximum was April 24th, 30.368 in.; the minimum was March 27th, 29.318 in. The mean of each of the months was, in March 29.888 in.; April, 29.778 in.; May, 29.863 in. The mean humidity was 61.59 deg., a little more than half saturation. The quantity of rain was, for March, 5.6 in.; for Aril, 3.45 in.; for May, 4.9 in. The whole amount for the spring 13.95 in., a little more than the average for 10 years.

The thermometer indicated a mean for March of 44.45 deg.; for April, of 53.33 deg.; and for May, of 61.84 deg. Mean for the spring, of 53.21 deg. It was at the highest on the 30th of May, 88.5 deg., at 2 P. M.; the lowest, on the 29th of March, 33 deg.; a range of 55.5 deg. for the 3 months.

Snow fell on 5 days; rain on 37 days; solar haloes occurred 5 times; lunar haloes 3 times; lunar coronas 2 times; Aurora Borealis 3 times; a meteor once, and thunder showers 7 times.

WOODEN NAILS.—In these days of millions of iron, copper and zinc nails, tacks and brads; of lightning, self-feeding, and almost automatic

nail machines, it is wonderful to find "wooden" nails coming into use. Yet that such is the fact the "Shoe and Leather Reporter" informs us. Wooden pegs, made by the same machines as shoe pegs, are now largely used for fastening boxes, and manufacturers receive large orders from the West for inch pegs for this purpose. In China, Japan, and Hindostan, pegs of bamboo have been always used in fastening tea chests and other wooden packages. In this age, however, it looks like retrogression to use wood for purposes for which iron seems so much better adapted. As one of the curious freaks of the habit, so inherent in human nature, to return to former customs under the impression that they are novelties, the above is noteworthy, but we do not anticipate a fall in cut nails from this cause.

A Useful Alloy.—A metal composition which may be cast on steel and iron and which will adhere thereto, is much needed, since it is in practice an advantage to unite steel or iron directly with brass by casting; the difficulty of uniting by screws, bolts, or pins, being thus saved. In most cases, however, the inequality of the expansion produced in the two metals by change of temperature prevents their lasting union, and it rarely happens that the superficial union is sufficiently close to be permanent. The following composition closes firmly around iron and steel without any danger of becoming loose. It consists of 3 parts of tin, 39½ parts of copper, and 7½ parts of zinc. Since the last metal is partly converted into vapor at a high temperature, the above proportion may be slightly increased.—*Technologist.*

Iron Slag for Street Pavements.—Some of our Western exchanges, particularly those of St. Louis, are much interested in discussing the practicability of utilizing iron slag for street pavements. Extensive experiments have been made with slag pavements in Brussels, as well as in France, during the past few months, and the results reached have been so favorable, that the attention of practical men in this country have been called to the subject. The slag which it is proposed to utilize in this way has heretofore had no commercial value. It is made in large quantities during the process of smelting iron ores, and has been cast aside as wholly useless, notwithstanding the fact that it contains on the average not less than 10 per cent. of pure iron—sufficient, if properly annealed, to impart indestructible toughness to the block and render the slag of great durability for paving purposes. Whether it can be so used or not depends, to a great extent, upon the cost of preparing it for use in this form. To reheat the slag, mould it into the required shape and bake it, would render it far more costly than the best paving stone. This can be avoided, however, with a little trouble and expense, if the iron manufacturers would have a mould on the "buggy," into which the slag could run when drawn off. When cool enough to be dumped, which it would be in a few minutes, it might be dumped into the ash pile, where, with but little trouble, it could be covered with the hot ashes constantly thrown out, and left to anneal itself by the most inexpensive process imaginable. If, as has been claimed, this process will sufficiently anneal the slag to divest it of that vitreous character which it possesses if cooled too rapidly, a cheap and superior article for street paving might be had wherever iron manufacture was carried on. In moulding the blocks, any desired size or pattern might be obtained, with no other expense than that of preparing the moulds. We can see no reason why this suggestion should not be turned to good account by the iron masters of Western cities, where desirable paving stones can only be be obtained from a considerable distance and at great expense. Properly prepared and laid slag pavement would be both economical and durable, and we can see no reason why it would not be as good, in all respects, as the best stone. Should it come into general use, the manufacture of slag blocks, even at a price low enough to enable them to compete successfully with wood and stone, would prove a source of no little profit to the iron masters, by enabling them to utilize what has not only been worthless, but an incumbrance.—*Iron Age.*

An improved "forge-lamp," for laboratory use, has been designed by Messrs. Delheid and Berge; and although it is essentially a modification of the Bunsen lamp, it is considered to possess important advantages. The forge-lamp consists of a "bougie burner," surmounted by a cylindrical chimney similar to that used with the Bunsen burner, but of rather greater diameter than that generally employed. This chimney descends below the gas outlet, and the air which mixes with it enters all round the jet. When the gaseous mixture is ignited above the chimney a strong draught is produced, which serves the purpose of a blowing apparatus. The air rushes in at the bottom of the chimney very energetically. But the flame from the burner would be very unsteady, and would be liable to be extinguished by a slight gust of air, were it not that this first tube is surrounded by a second of still larger diameter, so that the air for feeding the forge-lamp proper is compelled to pass through the annular space between the two tubes; thus, whilst keeping the apparatus cool, the air is warmed, which contributes to give the forge a great caloric intensity. Under these conditions the gas is very perfectly burned, and the current of air which burns the gas produces the same effect as if it were forced in by blowing. Compared with the Bunsen burners, the main distinguishing features of the forge-lamp are these: The air enters below the gas outlet, and not on a level, or above it, as is usual in Bunsen burners. A larger proportion of air is admitted than in Bunsen burners, as these have their supply of air simply from larger or smaller openings in the air tube, whilst the forge burner receives air from the whole extent of the section of the tube. And there is an additional cylinder which compels the air to cool the sides of the tube, and thus prevents the annoyance of the light running in. As to the results, the forge-lamp is claimed to surpass all apparatus of the kind hitherto proposed, by the extraordinary effect produced considered in relation to the small quantity of gas consumed, and by its extreme simplicity of construction.

Mr. Reid, the engineer of the Great Western of Canada line, has explained to the directors that they must not compare the American railroads of some years ago with the present ones, as they now carry much heavier loads on them, and run trains at a much greater speed, and that the largely increased expenditure upon the main-

tenance and renewals of the railroad have been, in a great measure, forced upon the company by the necessity of bringing up the efficiency of the permanent way to the same high standard as that now attained by the leading trunk lines between New York and Chicago. Those companies, Mr. Reid states, have expended very large sums upon their permanent way, and have so materially improved the condition of their tracks as to admit of their running through trains direct from New York to Chicago during the whole of the winter months at a high speed, and with almost as much regularity as during the summer months. He also states that it is intended to lay down in the track of the Great Western main line 3,000 tons of steel rails during the present half year, which, in addition to the re-rolled iron rails, and the ballasting and drainage works at present in progress, will go far to place the line on a footing of equality at the end of the present year with their rival and connecting lines in the State of New York and the Western States; and that a continuation of the same liberal outlay upon the main line to July, 1871, will, beyond doubt, enable the company to compete on equal terms with the best roadway of their rivals. This is the statement of Mr. Reid, and the company must therefore look forward to a large expenditure for the next six months, or perhaps longer. Steel rails will be laid on the steepest gradients where necessary, and the improved iron rails on the other portion of the track, so as to make the permanent way in all respects as good as that of the London and North-Western. The directors will remove the outside rail, which forms the broad gauge track, so as to leave the main line on the narrow gauge, and make it a most perfect road to meet every demand upon them for carrying traffic.

Wood may be rendered incombustible in a great measure, and preserved underground for a long time by the following process, proposed by Dr. Reinsch. The wood must not be planed, but placed for 24 hours in a solution of silicate of potassa in water, 1 part of the former to 3 of the latter. After removal, the wood is to be dried for several days, again soaked and dried, and then painted over with a mixture of 1 part cement to 4 parts of the liquid first used. Three coats of this paint to be applied. As the paint hardens rapidly, small quantities only should be used at a time. What results have been obtained as to durability by the process of Dr. Reinsch are not stated. Our manufacturers who desire a simpler and speedier process for the preservation of wood will find such in the substance for the preparation of the book-slates and blackboards, and also for the preservation of metals from acids and alkalies. Two coats of this solution, which is composed of some preparation of silicate suspended in a volatile liquid, will render wood fireproof, even under an intense heat, and render it also perfectly impervious to moisture. The paint, or solution, is cheap and efficacious, and also forms a perfect wood filling as a base for varnish.

A Peculiar Boiler Deposit.—This deposit was formed from Croton Water in a boiler, which, by a special arrangement of the steam-pipes, received the condensing waters back again. It had a light brown color, of the specific gravity of water, floating thereon, and had the following composition according to an analysis by Dr. Schweitzer:

Water	1.95	per cent.
Oil (extracted by ether)	20.76	"
Organic and volatile matter	45.23	"
Inorganic residue	26.06	"
The residue consisted of—		
Silicic acid	2.52	"
Stannic acid	1.68	"
Iron and alumina	3.62	"
Carbonate of lime	18.08	"
Magnesia	some.	
Sulphuric acid	none.	

These latter percentages apply to the original mass.—*American Gaslight Journal.*

Chinese Cement.—Among the crude materials sent by Dr. v. Scherzer, from Pekin, was the cement known as schio-liao, which is used in the north of China as paint for wood of all kinds, and by which these substances may be made perfectly water-proof. Dr. Scherzer saw in Pekin a wooden box which had travelled the tedious road via Siberia to St. Petersburg and back, which was found to be perfectly sound and water-proof. Even baskets made of straw became, by the use of this cement, perfectly serviceable in the transportation of oil. Pasteboard treated therewith receives the appearance and strength of wood. Most of the wooden public buildings of China are painted with schio-liao, which gives them an unpleasant reddish appearance, but adds to their durability. This cement was tried in the Austrian Department of Agriculture, and by the "Vienna Association of Industry," and in both cases the statements of Dr. Scherzer were found to be strictly accurate. It is prepared in the following manner: To 3 parts of fresh-beaten blood are added 4 parts of slaked lime and a little alum; a thin, pasty mass is produced, which can be used immediately. Objects which are to be made specially water-proof are painted by the Chinese twice, or at the most three times. This cement is not used for such purposes in this country, but it certainly deserves attention, as it is the cheapest really effectual means of rendering wood and other materials perfectly water-proof.—*Technologist.*

Lieutenant-Colonet Shakespear, R. A., is advocating the application of a telescope to the tangent scales of field-guns to meet the case of an enemy's artillery so skilfully posted as to be out of sight to unaided vision. He instances as an example of this the Russian batteries at Balaklava, charged by the Light Brigade, which he himself was reconnoitring through a telescope just before the charge, and which he believes might have been successfully engaged by our batteries had their exact position been earlier observed. Col. Shakespear suggests that a telescope fitted to a gun in the manner which he proposes might also—by a method which he explains—be employed as a "range-finder."

The several ships engaged in carrying the China cable (recently described) have arrived out at their destination, and the submergence of the cable is now supposed to be going on.

A newly discovered quarry of Kansas marble is 10 miles from Baxter Springs and covers 15,000 acres. It is in layers of 6, 8, and 18 in., and 3 to 4 ft. thick; pure white and mottled, and inexhaustible. The latter variety is tinged with pink. It takes a fine polish and finer edge.

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THE MONT CENIS TUNNEL.

BY FRANCIS KOSSUTH, C.E.

From "Engineering."

The construction of the tunnel under the Alps, between Bardonnèche and Modane, was commenced, in accordance with a Bill passed in the Italian Parliament, on the 15th of August, 1857. The official sanction to this Bill was given after the Committee appointed by the Government with the object of examining the project for the tunnel that had been presented by the Italian engineers, Messrs. Grattoni and Sommeiller, had delivered their report. This report referred especially to the mechanical appliances proposed for the carrying out of the work.

At the time that the Bill was issued the preparatory designs alone were ready, together with the models of the machinery with which the Government Commission had made their experiments. Although all the fundamental ideas of the engineers were clearly expressed, and the possibility of executing the work was materially proved by experiments before the colossal undertaking was commenced, the technical directors felt obliged to execute the working designs of the whole project, and to study carefully each separate part. This is why the preparatory and external works only could be proceeded with in the same year, 1857.

The plans previously developed under the direction of Mr. Mans, and followed out by his colleague, Mr. Bombeaux, an engineer of great experience and undoubted practical ability, were taken as a guide in deciding upon the works that were to be at once commenced on each side of Mont Frejus. The two chief points having been fixed, and the general direction of the axis of the tunnel having been approximately determined, excavation was begun at both extremities by hand labor alone, and continued till the mechanical system could be applied.

CONDITION OF THE LOCATION.

Before entering into further particulars, it may be found interesting to refer to the conditions of the locality in which the two industrial centres of the works were to be established, in order to give an idea of the difficulties encountered at the commencement of the works, and which could hardly be conceived by those who were unacquainted with the two miserable Alpine villages, Bardonnèche and Fourneaux, before the head works of the great tunnel were established close to them.

Bardonnèche is a village situated at an elevation of more than 4,200 ft. above the level of the sea, and in 1857 it was populated by a thousand inhabitants, a large proportion of whom, even now, being shepherds, migrate from the village during the summer months to remote feeding tracks. The whole population, with the exception of the small number that crosses over to the south of France, and especially

to Marseilles, live on the products of their own miserable fields, on their cattle, and by the rearing of mules. As the houses were built in accordance with the wants and very limited means of the people, and as their customs and mode of life were of the most primitive description, exceeding in poverty and rudeness those of the poorest villages of the plain, while, moreover, they passed the rigorous winter months crowded in stables amongst their cattle, it at first appeared hopeless to unite at Bardonnèche the necessary number of clerks and workmen to give a sufficient force at the commencement of the works. Not only were the most essential articles of food and of household necessaries wanting, but even the means of communication were insufficient for obtaining supplies. One of the first things to be done, therefore, was to provide for the repair and alteration of the houses, and at the same time to encourage the primitive arts and industries, without which it would have been excessively expensive, if not impossible, to keep the workmen in such a place.

Under these circumstances, for above two years, the engineers, clerks, and operatives had to submit to discomfort hardly conceivable by persons who have not lived in those wild Alpine districts during the winter season.

At Fourneaux the conditions of the locality were no better. Fourneaux is a village numbering barely 400 inhabitants, absolutely without any means whatever of ministering to the wants of an increased population. There were no lodgings, except in filthy stables, and no shops where the workmen could purchase an ounce of eatable food. The clerks and workmen were forced to quarter themselves at Modane, a village of some importance, but more than a mile and a quarter from Fourneaux, and for three years all were obliged to walk that distance, over rocks, marsh, and morass, three or four times a day, exposed to all the inclemency of an extremely severe climate, and sometimes through snow five feet in depth.

Such were the conditions under which the external and preparatory works were begun.

These works consisted at first almost exclusively of masonry; and as building is very tedious in these regions, the progress was slow, for the masons can only calculate six months in which they can work, and even out of this time they must lose many days on account of bad weather.

CHRONOLOGICAL ORDER OF THE FIELD WORKS.

The tracing of the axis of the tunnel was of the greatest importance, and it had to be undertaken and carried out as quickly as possible, so as to permit of the commencement of the excavation at both ends.

The problem to be solved was: 1. To fix across the mountain several points, which would all be contained in the vertical plane drawn through the axis of the tunnel; 2. To obtain the exact length between the openings; 3. To know the precise difference of level between the two extremities of the tunnel, so as to obtain the proper gradients.

These labors were first assigned to Messrs. Borelli and Copello, civil engineers. The first operation was to trace a trial line from the fixed point from the opening at Fourneaux towards Bardonnèche. This line, which was traced as rapidly as the position of the locality could permit, and with such a degree of accuracy as is necessary for a trial tracing, intersected the valley of Rochesmolles at a point much higher up in the valley than that previously fixed for the southern opening. Being guided by this first tracing, and re-starting from the northern opening, a second line was located, which terminated near Bardonnèche, very close to the spot which was aimed at.

Again, taking the second tracing as a guide, a third axis was finally traced, which fully corresponded to the proposed conditions, as it passed by both the points previously fixed for the openings of the tunnel in the valleys of Arc and Rochesmolles. These first operations, although accomplished with the greatest possible dispatch, and though the season was constantly favorable, could not be completed before the beginning of September, for much of the time was taken up by journeying to and fro between the opposite sides of the mountain, and also owing to the rugged and difficult nature of the ground over which the line had to be laid out. The approximate axis of the tunnel having thus been determined, it yet remained to be traced out in a definite and permanent manner, in order that the fixed signals might be set up, and the

exact points found at which the observatories were to be erected at each opening, as well as at the highest point of the mountain. This was done in the month of September, while excursions were also made to the highest peaksof the principal chain and of the adjacent mountains, with the view of finding out the trigonometrical points of the Royal Engineering staff survey, and to fix the others, which would suit best as vertices of future triangulation. At the beginning of October, 1857, the most important fixed signals on the northern side, and all those on the southern, were definitely fixed, as well as the corresponding points of the observatory of the southern opening; and there only remained to decide the spot which was afterwards to serve for the northern observatory, and to fix definitely some secondary signals on the northern side of the mountain. At that time Mr. Borelli was called upon to superintend the local direction of the works, begun at Baronnèche, and it fell to the lot of Mr. Copello to complete the work still unfinished, relative to the tracing of the tunnel. The first falls of snow prevented the field work from being completed till about the middle of October, and on the 20th of this month such difficulties were met with in consequence of snow and wind, that the idea of continuing any work in that year had to be given up. At the same time, in which the tracing of the axis was going on, levelling was commenced along the mountain, direct from one opening to another, crossing the peak near Frejus, following as nearly as possible the axis traced on the mountain; and on the route were placed a number of altimetrical signals to be used in controlling the operations. The results of this levelling, after having been done twice, although not considered definite, were sufficiently in accordance to warrant the prosecution of the excavation at each end of the tunnel; especially as it was easy to compensate for the slight changes which might still be necessary to introduce in the arrangement of the gradients, when the ultimate studies for fixing the exact difference of level between the two entrances, and the precise length of the tunnel had been completed.

Towards the middle of July of the following year (1858), the trigonometrical operations which still remained to be done, were set in hand. These operations were preceded by the selection of those culminating points which were found to be best adapted to form the most suitable system of triangles, and the choice of a base among the sides previously traced out by the engineering staff, for the general survey of the country. This work, which took up all the second half of July, was executed by Mr. Copello. When the triangulation was completed, and the base of one of the triangles of the engineering staff, with which the new triangulation had to be brought into geodetical connection, was chosen, the measurement of the angles of the system was immediately proceeded with, beginning from the highest vertices, and descending by degrees to the lowest points; first, on the side of Bardonneche, and then on that of Modane. The complete operation, which includes 21 geodetical stations, and as many as 86 measured angles, each of which was checked over at least 10 times, could not be finished before the beginning of October, 1858. In the same time, however, all the special points of the longitudinal section on the axis of the tunnel could be divided out with sufficient exactitude; the respective distances being deduced, either by direct measurement or by the solution of the minor triangles (tied to the principal system), and the heights of which, found by direct levelling, were brought into geodetical connection with the fixed altimetrical signals across Mont Frejus.

During this period the observatory, placed on the highest point of the mountain, was erected, and having thus assured for the instrument and the operator a shelter against the furious winds which rage on those bare rocks, the tracing of the axis of the gallery could be re-undertaken and verified with the greatest possible precision. Finally, in that same surveying campaign, Mr. Mondino again completed a set of direct levels between the headings of the tunnel, by which new operation the difference of their respective altitudes was ascertained with perfect accuracy. At the end of the season, 1858, all the surveys relating to the alignment and to the length of the tunnel were terminated, and everything was ready to compile the longitudinal section along the axis of the tunnel.

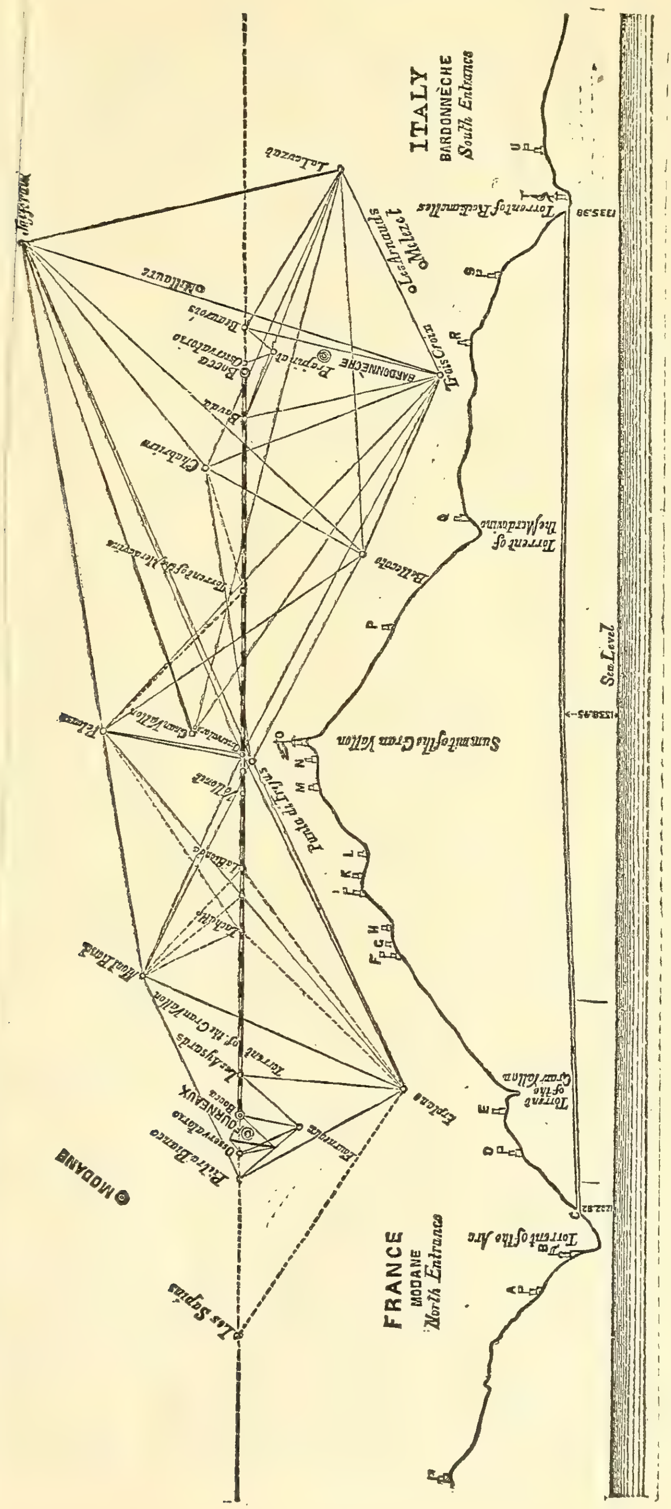
Having thus sketched out in chronological order the different preliminary surveying and levelling operations, which were undertaken to ascertain the exact position and the gradient of the work, as well as for the measurement of its length; and having given an historical account of the various operations carried out in tracing the axis of the Mont Cenis Tunnel, we shall now proceed to describe the method followed in their execution, in order to obtain such a degree of accuracy as could be relied upon with absolute certainty. The longitudinal section represented in the annexed engraving, will explain the reason for the method which was adopted. Looking from the summit of the Grand Vallon, which stands almost midway between the two entrances of the tunnel, and on the highest point of the chain intersected by its axis, it will be seen that the southern side towards Bardonnèche, offers only two remarkable points, the one at Q, which marks the crossing of the torrent Merdovine, and the other, S, which is on the summit of Banda. On the northern side there is a spur which commences near the observatory placed on the top of the mountain; and then continues sloping downwards, following very nearly the direction of the axis of the tunnel, by which it is met in three places, M, T, and F, corresponding to Vallonet, LaRionda, and Lachalle, so called from the names of the summits on which they stand.

Between Lachalle and the bottom of the Valley of the Arc, the only remarkable point on the side of the mountain is at E, where the line meets with the torrent of the Grand Vallon. The axis of the tunnel being prolonged on the southern side, beyond the torrent Rochemolles, the Millaures are met with, and here the extreme point, U, was fixed in such a manner that the visual line passing through it, and the observatory of the Grand Vallon should be tangential to the peak of Banda. On the northern side, the axis of the tunnel being prolonged across the Valley of the Arc, and extended on the southern side of the same, the observatory, B, of the entrance was erected, as well as the signal A, of Pietra Bianca. It is easy to perceive that in order to obtain a point from which a visual line could be drawn to the principal observatory, it would be necessary to ascend to a great height because of the Grand Vallon, and therefore the extreme point of the line on this side had to be fixed at a long distance from the north opening, and at a considerable height.

When the approximate axis was determined, so as to meet the required conditions, namely, to pass through the two points fixed for the opening of the tunnel, the points where the principal observatory of the Grand Vallon was to stand, as well as that on the southern side of the Valley of the Arc, which was to be the extreme point of Les Sapins, were definitely established. From the observatory of the Grand Vallon a third point was next fixed, which, as we have said, was the extreme station situated beyond the valley of Rochemolles at Beauvoir.

This very simple operation which included all the tracing, was repeated and verified many times by various methods and from different observatories; the instrument used was a large theodolite by Lerieux, of Paris, and by means of it the signal placed at Les Sapins was distinctly seen from the observatory of the Grand Vallon, although the distance between them was more than 9,840 yards.

It was impossible to execute the tracing of the axis in the usual manner, that is to say, so that the ends of the line might be visible one from the other, unless at such a distance as to cause serious chances of error in the precision of the observations, whereas even if any mistake inseparable from the workmanship of the instrument, and from the method used, had occurred in following out the system just described (*i.e.*, of prolonging the axis beyond the two entrances, and choosing an intermediate point where the extended terminal points could be seen), the error would not have been of great consequence, because if, for example, the mistake consisted in an angle of deviation, by turning the instrument round 180 deg., such an angle could only differ from the one given by the first observation of the vernier of the theodolite by at the utmost 10 sec., that is to say, the observatory of the grand Vallan, instead of being placed on a straight line drawn between the two entrances, would be at the vertex of two lines diverging at an angle of 10 sec.; now, such a mistake, at the utmost, would give a deviation of 11.42 in., a deviation to be remedied so easily as to give rise to


ITALY
BARDONNÈCHE
South Entrance
FRANCE
MODANE
North Entrance
Sea Level
Sommet of the Gran Vallon
Tours Croix
MODANE
Los Sapins
FOURNEAUX
Torrent of the Arc

no serious apprehensions upon the definitive result of the undertaking.

The line having been selected by means of the Les Sapins, the observatory of the Grand Vallon, and Beauvoir, there existed no difficulty in fixing the other points. The south opening was marked by sighting Banda, S, from Beauvoir, U, and then aiming with the instrument from Banda to Beauvoir, was established the southern observatory, T, from which the opening was worked. A similar operation for the north opening was something more tedious to carry out, for it was necessary, when sighting with the instrument from the observatory of the Grand Vallon to Les Sapins, first to sight Vallonet, M, and then, having removed the instrument to this position, to continue the collimation, first to the extreme point on the southern side of the Arc, to mark the Rionda, I, and the Pietra Bianca, A, then again to remove the instrument to the Rionda, and fix successively Les Sapins and Pietra Bianca, to mark Lachalle, F, when, having carried the instrument to this last point, and finally collimating at Les Sapins and Pietra Bianca, the position of the northern observatory, B, could be marked, and from it the northern opening and another secondary point at Les Aysards, D. The configuration of the ground, which has already been described, made it necessary that all these successive references from one point to the preceding, should be made. Of the exactness of the operation, however, no doubt can be entertained, if it be remembered that the point to be fixed was very near the observer, whereas, on the contrary, the point sighted with the instrument, while fixing the former, was at a considerable distance.

The most important peak on the northern side (owing to its being the furthest that could be sighted from an observatory at the opening), and which served to check the line of the tunnel, is Lachelle, and it may be considered as fixed with the greatest exactness, so that if even here some mistake had been made, the consequences would not have seriously affected the final result.

On the southern side of the mountain the point sighted for the tracing of the tunnel was Banda, this being the only one visible from the observatory of Bardonnèche, and which was only about 2,624 ft. from it; this short distance could not have been thoroughly relied upon if the position in which it was placed had not been fixed with the greatest precision; in fact, we mentioned that the visual line from the observatory of the Grand Vallon to the extreme signal at Beauvoir, passed over that of Banda, so that this point was fixed at the first moment, without any vertical movement being made in the telescope of the instrument.

The trigonometrical survey made to obtain the means for measuring the length of the tunnel had for its base the side, Grand Vallon, Jafferau (see the plan), afforded by the data of the royal engineering staff, and which, though not belonging to a triangle of the first order, is tied directly to one.

The length of this side is 28,544.93 ft., and one of its extremities is at a little distance from the principal observatory of the Grand Vallon, while the other, elevated 9,184 ft. above the level of the sea, is the vertex of that mountain which, on the left of the Dora, overlooks the two valleys of Oulx and Bardonnèche; it is also well to mention that the distance between the opening and the observatory of Bardonnèche was measured direct, and it was found to be 465.97 ft.

The whole of the trigonometrical system may be divided into two distinct systems of triangles; the first includes the base and those triangles which extend to the south of the principal chain, and the second includes the triangles on the opposite side, leaving the two systems bound together by having one side in common, the extreme points of which are on the top of the same chain.

The whole system consisted of 28 triangles, the complete number of measured angles 86, all of which were repeated not less than 10 times, the greater part 20, and the most important even 60 times. As regards the instrument with which the angles were measured, a Gambey's theodolite was employed, the vernier of which gave at the first reading 5 sec. approximation. As regards the exactness of the operations mentioned above, we may observe that the frequent cases of verification which occurred while tracing out of the triangles was in progress, and which from different points gave the same result, had necessarily diminished the chance of mistakes to such an extent that no ap-

prehensions could be entertained as to the precision of the final result. And, even if an error had been committed, which might have caused an alteration of 14 or 18 ft. in the whole length of the tunnel, the modifications that would have been involved by this difference of length in laying out its gradients, would have been almost imperceptible, and no danger would have arisen through it, so far as regards the meeting of the two sections of the tunnel excavated from each end.

The operations of levelling were executed by means of very exact instruments. The level path passed Mont Frejus, which is the mountain nearest to the tracing, and it was laid out with numerous fixed points (one at every 164 ft. in elevation), arranged to assist in checking the work, to limit errors, and to facilitate their discovery. As we have before said, this levelling was done, and afterwards repeated by Mr. Mondino in the autumn of 1857, and also in 1858, which repetition only gave a difference in the whole length of less than 3.93 in. Afterwards Mr. Lermine again checked the operation, and through him the error was reduced to only 1.574 in.

The fixed points afforded the advantage of ascertaining whether perfect accuracy existed at each step, and in case of a difference it was only necessary to repeat the levelling between the two points where the difference occurred. In this manner the longitudinal section along the axis was obtained; this, however, was only a matter of scientific interest.

The Mont Cenis Tunnel unites two points on the opposite sides of Mont Frejus, the position of which is such as to necessitate the two ends of the great work being constructed on a curve. This circumstance, however, was not taken into account at first, and temporary entrances were opened on both sides of the mountain in order to have the whole axis of the gallery in a straight line, and thus to diminish the chances of any error; in order, also, to obtain ventilation, and, above all, the transmission of motive power to facilitate the working of the mechanical boring appliances. The preliminary measurements gave a distance of 13,861.5 yards between the two temporary headings.

It was necessary to construct the tunnel with two gradients, both rising from the entrances, and meeting with a summit level at an intermediate point of its length. This was decided upon, as well to provide an easy means of getting rid of the water, as to increase the chances of making a fair meeting with the two headings. From the Bardonnèche entrance, 4,408.5 ft. above the sea, the calculation gave a gradient of 1 in 2000 for a distance of 20997.33 ft. From the Fourneaux entrance, 3945 fi. above the sea, the rising gradient was 1 in 43.4782 for 20,587 ft.

The two gradients terminated therefore in the summit level at an estimated height of 4,418.50 ft.

Thus far the figures based upon the data have been found by calculation.

The actual figures, however, differ somewhat from these, the variations having proceeded from small discrepancies that were discovered, whilst the final line of the tunnel was being traced, as well as from errors made in the precise levels of the starting points.

The absolute figures are as follows :—

Total length of the tunnel......	13364.86 yds.
Elevation above the sea level of the Bardonnèche entrance....	4381.25 ft.
Rise of 1 in 2000 for 200408.1 ft.	10.024
Summit level from Bardonnèche	4391.274
Elevation above sea level at the Fourneaux entrance	3946.50
Rise of 1 in 45.045 for 20045.1 ft.	445.00
Summit level from Fourneaux end	4391.50

—showing a slight difference from the calculations of the summit level as reckoned at Bardonnèche, and giving a mean level for the highest point of 4,391.386 ft.

To complete these data, we will add that the vertical plane of the tunnel forms an angle of 19 deg. with the terrestrial meridian, and that the greatest height of the mass of the mountain over the tunnel is 5,307 ft.

It will be easily understood, from what we have already stated, that the surveying operations, though not such as to present extraordinary difficulties, were, nevertheless, rendered by no means easy, on account of the local and atmospheric conditions, to say nothing of the necessity of daily ascents and descents of from 2,500 to 3,000 ft.; the rapid and successive changes in the temperature, of fog, snow, wind, and sun, which often rendered any work quite impossible; for it rarely happened, on account of the inclemency of the cli-

mate, that more than two consecutive angles could be measured, and many times not even one could be observed. This explains the long time taken up by the field work.

Before concluding our remarks on the geodetical works, we think it would be well to say a few words about the railroads which are to join the openings of the tunnel with the Turin, Susa, Chambery, and Saint-Michel lines. Messrs. Borelli and Massa had the direction of the works upon the Italian side of the Alpine railway.

The ruling gradient on this railway is 1 in 33.33 on the open lengths, and 1 in 40 in tunnels which are of considerable length; the minimum radius of curves is 22⅓ chains; this last limit was, however, never required for the radii of the curves along this road. The railroad which unites the Turin-Susa line to the entrance of the great tunnel is 24.85 miles in length.

The difference of the level between the spot where the Alpine railway branches off from the Susa line at Bussoleno and the station of Bardonnèche is 2536 ft., so that the mean gradient of all the line would hardly have been more than 1 in 52, and thus it may at first sight seem that the inclines might have been limited to 1 in 40, but local circumstances prevented the gradients from being reduced to this inclination.

On this short railroad there will be not less than eighteen tunnels, three of which are more than a kilometre in length. The torrent Dora, and the frequent ravines and precipices, are crossed by bold bridges and viaducts, some of the arches of which are 90 ft. span.

As to the railroad which is to unite the northern opening of the tunnel with Saint-Michel, according to the first plans, it should have begun at Saint-Michel and skirted the left bank of the Arc as far as Freney, a little village that is encountered before reaching Fourneaux; at this spot it was intended by means of a bridge to cross the Arc, and to follow its course on the right bank to Modane, where it was to be crossed again by another bridge, and, continuing on the left bank, it was to unite the tunnel, windings in the road being necessary in order to gain the difference of 348 ft. in the level between the plain of Fourneaux and the north opening of the tunnel. Upon after consideration, however, the railroad was taken along the left bank of the Arc, and reached the tunnel by means of a viaduct 262 ft. 6 in. in length.

Having described, in considerable detail, the means adopted for laying out the direction of the Mont Cenis Tunnel, and the system of triangulation employed, we shall now proceed to consider the method used for maintaining the direct line of the axis of the tunnel while the work of excavation was being carried on. The observatories, B and T (see engraving), placed at the entrances of the tunnel, were used for the necessary observations, and both of the observatories contain an instrument constructed for the purpose. This instrument was placed on a pedestal of masonry, the top of which was covered with a horizontal slab of marble, having engraved upon its surface two intersecting lines marking a point, which was exactly in the vertical plane containing the axis of the tunnel. The instrument was formed of two supports, fixed on a tripod, having a delicate screw adjustment. The telescope was similar to that of a theodolite, provided with cross webs, and strongly illuminated by the light from a lantern concentrated by a lens, and projected upon the cross webs. In using this instrument, in checking the axis of the gallery at the northern entrance, for example, after having proved precisely, that the vertical plane, corresponding with the point of intersection of the lines upon the slab also passed through the centre of the instrument, a visual line was then conveyed to the station at Lachalle (F), and on the instrument being lowered, the required number of points could be fixed in the axis of the tunnel.

In executing such an operation it was necessary that the tunnel should be free from smoke or vapor. The point of collimation was a plummet suspended from the roof of the tunnel by means of an iron rectangular frame, in one side of which a number of notches were cut, and the plummet was shifted from notch to notch, in accordance with the signals of the operator at the observatory. These signals were given to the man whose business it was to adjust the plummet by means of a telegraph or a horn. The former was found invaluable throughout all these operations.

At the Bardonnèche entrance the instrument employed in setting out the axis of the tunnel was similar to the one already described, with the exception that it was mounted on a little carriage, resting on vertical columns that were erected at distances of 500 metres apart in the axis of the tunnel. By the help of the carriage the theodolite was placed first on the centre line approximately; it was then brought exactly into line by a fine adjusting screw, which moved the eyepiece without shifting the carriage. In order to understand more clearly the method of operating the instrument, the mode of proceeding may be described. In setting out a prolongation of the centre line of the tunnel the instrument was placed on the last column but one ; a light was stationed upon the last column, and exactly in its centre, and 500 metres ahead, a trestle frame was placed across the tunnel. Upon the horizontal bar of this trestle several notches are cut, against which a light was placed and fixed with proper adjusting screws. The observer standing at the instrument caused the light to move on the trestle frame until it was brought into an exact line with the instrument and the first light, and then the centre of the light was projected with a plummet on to the ground, and in this way the exact centre was found.

By a repetition of similar operations the vertical plane containing the axis of the tunnel was laid out by a series of plummet lines. During the intervals of time that elapsed between consecutive operations with the instrument, the plummets were found to be sufficient for maintaining the direction in making the excavation.

To maintain the proper gadients in the tunnel it was necessary at intervals to establish fixed levels, deducing them by direct levelling from standard bench marks placed at short distances from the entrances. The fixed level marks in the inside of the tunnel are made upon stone pillars placed at intervals of 25 metres, and to these were referred the various points in setting out the gradients. In our next article we shall treat of the geological features of the district through which the tunnel passes.

THE USEFULNESS OF EARTHQUAKES.

By R. A. PROCTOR, B. A.

From "Light Science for Leisure Hours."

We have often had fearful evidence of the energy of the earth's internal forces. A vibration which, when considered with reference to the dimensions of the earth's globe, may be spoken of as an indefinitely minute quivering limited to an insignificant area, has sufficed to destroy the cities and villages of whole provinces, to cause the death of thousands of human beings, and to effect the destruction of property which must be estimated by millions of pounds sterling. Such a catastrophe as this serves, indeed, to show how poor and weak a creature man is in the presence of the grand workings of Nature. The mere throes which accompany her unseen subterranean efforts suffice to crumble man's strongest buildings in a moment into the dust, while the unfortunate inhabitants are either crushed to death among the ruins, or forced to remain shuddering spectators of the destruction of their homes.

At first sight it may seem paradoxical to assert that earthquakes, fearfully destructive as they have so often proved, are yet essentially preservative and restorative phenomena ; yet this is strictly the case. Had no earthquakes taken place in old times, man would not now be living on the face of the earth ; if no earthquakes were to take place in future, the term of man's existence would be limited within a range of time far less than that to which it seems likely, in all probability, to be extended.

If the solid substance of the earth formed a perfect sphere in ante-geologic times—that is, in ages preceding those to which our present geologic studies extend —there can be no doubt that there was then no visible land above the surface of the water ; the ocean must have formed a uniformly deep covering to the submerged surface of the solid globe. In this state of things, nothing but the earth's subter-

ranean forces could tend to the production of continents and islands. Let us be understood. We are not referring to the possibility or impossibility that lands and seas should suddenly have assumed their present figure without convulsion of any sort; this *might* have happened, since the Creator of all things can doubtless modify all things according to His will; we merely say that, assuming that in the beginning as now He permitted all things to work according to the laws He has appointed, then, undoubtedly, the submerged earth must have risen above the sea by the action of those very forms of force which produce the earthquake in our own times.

However this may be, it is quite certain that when once continents and islands had been formed, there immediately began a struggle between destructive and restorative (rather, perhaps, than preservative) forces.

The great enemy of the land is water, and water works the destruction of the land in two principal ways.

In the first place the sea tends to destroy the land by beating on its shores, and thus continually washing it away. It may seem at first sight that this process must necessarily be a slow one; in fact, many may be disposed to say that it is certainly a slow process, since we see that it does not alter the forms of continents and islands perceptibly in long intervals of time. But, as a matter of fact, we have never had an opportunity of estimating the full effects of this cause, since its action is continually being checked by the restorative forces we shall presently have to consider. Were it not thus checked, there can be little doubt that its effects would be cumulative; for the longer the process continued—that is, the more the land was beaten away—the higher would the sea rise, and the greater power would it have to effect the destruction of the remaining land.

We proceed to give a few instances of the sea's power of effecting the rapid destruction of the land when nothing happens to interfere with the local action—premising that this effect is altogether insignificant in comparison with that which would take place, even in that particular spot, if the sea's action were *everywhere* left unchecked.

The Shetland Isles are composed of substances which seem, of all others, best fitted to resist the disintegrating forces of the sea—namely, granite, gneiss, mica-slate, serpentine, greenstone, and many other forms of rock; yet, exposed as these islands are to the uncontrolled violence of the Atlantic Ocean, they are undergoing a process of destruction which, even within historical times, has produced very noteworthy changes. "Steep cliffs are hollowed out," says Sir Charles Lyell, "into deep caves and lofty arches; and almost every promontory ends in a cluster of rocks, imitating the forms of columns, pinnacles, and obelisks." Speaking of one of the islands of this group, Dr. Hibbert says:—"The isle of Stenness presents a scene of unequalled desolation. In stormy winters, large blocks of stone are overturned, or are removed from their native beds, and hurried to a distance almost incredible. In the winter of 1802, a tabular mass, 8 ft. 2 in. by 7 ft., and 5 ft. 1 in. thick, was dislodged from its bed and carried to a distance of from 80 to 90 ft. In other parts of the Shetland Isles, where the sea has encountered less solid materials, the work of destruction has proceeded yet more effectively. The Roeness, for example, the sea wrought its way so fiercely, that a large cavernous aperture 250 ft. long has been hollowed out. "But the most sublime scene," says Dr. Hibbert, "is where a mural pile of porphyry, escaping the process of disintegration that is devastating the coast, appears to have been left as a sort of rampart against the inroads of the ocean. The Atlantic, when provoked by wintry gales, batters against it with all the force of real artillery; and the waves, in their repeated assaults, have at length forced for themselves an entrance. This breach, named the Grind of the Navir, is widened every winter by the overwhelming surge that, finding a passage through it, separates large stones from its sides, and forces them to a distance of no less than 180 ft. In two or three spots, the fragments which have been detached are brought together in immense heaps, that appear as an accumulation of cubical masses, the product of some quarry."

Let us next turn to a portion of the coast-line of Great Britain which is neither defended, on the one hand, by barriers of rock, nor attacked, on the other, by the full fury of the Atlantic currents. Along the whole coast of Yorkshire, we

find evidence of a continual process of dilapidation. Between the projecting headland of Flamborough and Spurn Point (the coast of Holderness), the waste is particularly rapid. Many spots, which are now mere sand-banks, are marked in the old maps of Yorkshire as the sites of ancient towns and villages. Speaking of Hyde (one of these), Pennant says : "Only the tradition is left of this town." Owthorne and its church have been for the most part destroyed, as also Auburn, Hartburn, and Kilnsea. Mr. Phillips, in his "Geology of Yorkshire," states that not unreasonable fears are entertained that, at some future time, Spurn Point itself will become an island, or be wholly washed away, and then the ocean, entering into the estuary of the Humber, will cause great devastation. Pennant states that "several places, once towns of note upon the Humber, are now only recorded in history ; and Ravensperg was at one time a rival of Hull, and a port so very considerable in 1332, that Edward Baliol and the confederate English barons sailed from hence to invade Scotland ; and Henry IV., in 1399, made choice of this port to land at, to effect the deposal of Richard II. ; yet the whole of this has since been devoured by the merciless ocean ; extensive sands, dry at low water, are to be seen in their stead." The same writer also describes Spurn Point as shaped like a sickle, and the land to the north, he says, was "perpetually preyed on by the fury of the German Sea, which devours whole acres at a time."

The decay of the shores of Norfolk and Suffolk is also remarkably rapid. Sir Charles Lyell relates some facts which throw an interesting light on the ravages which the sea commits upon the land here. It was computed that when a certain inn was built at Sherringham, 70 years would pass before the sea could reach the spot : "the mean loss of land being calculated from previous observations to be somewhat less than 1 yard annually." But no allowance had been made for the fact that the ground sloped *from* the sea. In consequence of this peculiarity, the waste became greater and greater every year as the cliff grew lower. "Between the years 1824 and 1829, no less than 17 yards were swept away;" and when Sir Charles Lyell saw the place, only a small garden was left between the building and the sea. We need hardly add that all vestiges of the inn have long since been swept away. Lyell also relates that, in 1829, there was a depth of water sufficient to float a frigate at a point where, less than half a century before, there stood a cliff 50 ft. high with houses upon it.

We have selected these portions of the coast of Great Britain, not because the destruction of our shores is greater here than elsewhere, but as serving to illustrate processes of waste and demolition which are going on around all the shores, not merely of Great Britain, but of every country on the face of the earth. Here and there, as we have said, there are instances in which a contrary process seems to be in action. Low-lying banks and shoals are formed—sometimes along stretches of coast extending for a considerable distance. But when we consider these formations closely, we find that they rather afford evidence of the energy of the destructive forces to which the land is subject than promise to make up for the land which has been swept away. In the first place, every part of these banks consists of the *debris* of other coasts. Now we cannot doubt that of earth which is washed away from our shores, by far the larger part finds its way to the bottom of the deep seas ; a small proportion only can be brought (by some peculiarity in the distribution of ocean-currents, or in the progress of the tidal wave) to aid in the formation of shoals and banks. The larger, therefore, such shoals and banks may be, the larger must be the amount of land which has been washed away never to reappear. And although banks and shoals of this sort grow year by year larger and larger, yet (unless added to artificially) they continue always either beneath the surface of the water, in the case of shoals, or but very slightly raised above the surface. Now, if we suppose the destruction of land to proceed unchecked, it is manifest that at some period, however remote, the formation of shoals and banks must come to an end, owing to the continual diminution of the land from the demolition of which they derive their substance. In the mean time, the bed of the sea would be continually filling up, the level of the sea would be rising, and thus the banks

would either be wholly submerged through the effect of this cause alone, or they would have so slight an elevation above the sea-level that they would offer little resistance to the destructive effects of the sea, which will now have no other land to act upon.

But we have yet to consider the second principal cause of the wasting away of the land. The cause we have just been dealing with acts upon the shores or outlines of islands and continents; the one we have now to consider acts upon their interior. It will, perhaps, hardly be supposed that the fall of rain upon the land could have any appreciable influence in the demolition of continents; but, as a matter of fact, there are few causes to which geologists are disposed to ascribe more importance. The very fact that enormous deltas have been formed at the mouths of many rivers—in other words, the actual growth of continents through the effects of rainfall—is a proof how largely this cause must tend to destroy and disintegrate the interiors of our continents. Dwelling on this point, Sir Charles Lyell presents the following remarkable illustration: "During a tour in Spain," he writes, "I was surprised to see a district of gently undulating ground in Catalonia, consisting of red and gray sandstone, and in some parts of red marl, almost entirely denuded of herbage; while the roots of the pines, holm oaks, and some other trees, were half exposed, as if the soil had been washed away by a flood. Such is the state of the forests, for example, between Oristo and Vich, and near San Lorenzo. But, being overtaken by a violent thunder-storm in the month of August, I saw the whole surface, even the highest levels of some flat-topped hills, streaming with mud, while on every declivity the devastation of torrents was terrific. The peculiarities in the physiognomy of the district were at once explained; and I was taught that, in speculating on the greater effects which the direct action of rain may once have produced on the surface of certain parts of England, we need not revert to periods when the heat of the climate was tropical."

Combining the effects of the sea's action upon the shores of continents, and of the action of rain upon their interior, and remembering that unless the process of demolition were checked in some way, each cause would act from year to year with new force—one through the effects of the gradual rise of the sea-bed, and the other through the effects of the gradual increase of the surface of ocean exposed to the vaporizing action of the sun, which increase would necessarily increase the quantity of rain yearly precipitated on the land—we see the justice of the opinion expressed by Sir John Herschel, that, "had the primeval world been constructed as it now exists, time enough has elapsed, and force enough directed to that end has been in activity, *to have long ago destroyed every vestige of land.*"

We see, then, the necessity that exists for the action of some restorative or preservative force sufficient to counteract the effects of the continuous processes of destruction we have indicated above. If we consider, we shall see that the destructive forces owe their efficiency to their levelling action, that is, to their influence in reducing the solid part of the earth to the figure of a solid sphere; therefore the form of force which is required to counteract them is one that shall tend to produce irregularities in the surface-contour of the earth. And it will be remarked, that although *upheaval* is the process which appears at first sight to be the only effectual remedy to the levelling action of rains and ocean-currents, yet the forcible depression of the earth's surface may prove in many instances yet more effective, since it may serve to reduce the sea-level in other places.

Now, the earth's subterranean forces serve to produce the very effects which are required in order to counteract the continual disintegration of the shores and interior parts of continents. In the first place, their action is not distributed with any approach to uniformity over different parts of the earth's crust, and therefore the figure they tend to give to the surface of that crust is not that of a perfect sphere. This, of itself, secures the uprising of some parts of the solid earth above the sea-level. But this is not all. On a comparison of the various effects due to the action of subterranean forces, it has been found that the forces of upheaval act (on the whole) more powerfully under continents, and especially under the shore-lines of continents, while the forces of depression act most powerfully (on the

whole) under the bed of the ocean. It need hardly be said that whenever the earth is upheaved in one part, it must be depressed somewhere else. Not necessarily at the same instant, it should be remarked. The process of upheaval may be either momentarily accompanied by a corresponding process of depression, or the latter process may take place by a gradual action of the elastic powers of the earth's crust; but, in one way or the other, the balance between upheaval and depression must be restored. Hence, if it can be shown that for the most part the forces of upheaval act underneath the land, it follows—though we may not be able to recognize the fact by obvious visible signs—that processes of depression are taking place underneath the ocean. Now, active volcanoes mark the centre of a district of upheaval, and nearly all volcanoes are found near the sea. It seems as if Nature had provided against the inroads of the ocean by seating the earth's upheaving forces just where they are most wanted.

Even in earthquake districts which have no active vent, the same law is found to prevail. It is supposed by the most eminent seismologists that earthquake regions around a volcano, and earthquake regions apparently disconnected from any outlet, differ only in this respect, that in the one case the subterranean forces have had sufficient power to produce the phenomena of eruption, while in the other they have not. "In earthquakes," says Humboldt, "we have evidence of a volcano-producing force; but such a force, as universally diffused as the internal heat of the globe, and proclaiming itself everywhere, rarely acts with sufficient energy to produce actual eruptive phenomena; and when it does so, it is only in isolated and particular places."

Of the influence of the earth's subterranean forces in altering the level of land, we might quote many remarkable instances, but considerations of space compel us to confine ourselves to two or three. The slow processes of upheaval or depression may, perhaps, seem less immediately referrible to subterranean action than those which are produced during the progress of an earthquake. We pass over, therefore, such phenomena as the gradual uprising of Sweden, the slow sinking of Greenland, and (still proceeding westward) the gradual uprising of Nova Scotia and the shores of Hudson's Bay. Remarkable and suggestive as these phenomena really are, and indisputable as the evidence is on which they rest, they will probably seem much less striking to our readers than those which we are now about to quote.

On the 19th of November, 1822, a widely-felt and destructive earthquake was experienced in Chili. On the next day, it was noticed for the first time that a broad line of sea-coast had been deserted by the sea for more than 100 miles. A large part of this tract was covered by shell-fish, which soon died, and exhaled the most offensive effluvia. Between the old low-water mark and the new one, the fisherman found burrowing shells, which they had formerly had to search for amidst the surf. Rocks some way out to sea which had formerly been covered, were now dry at half ebb-tide.

Careful measurement showed that the rise of the land was greater at some distance inshore than along the beach. The watercourse of a mill about a mile inland from the sea had gained a fall of 14 in. in little more than 100 yards. At Valparaiso the rise was 3 ft.; at Quintero, 4 ft.

In February, 1835, and in November, 1837, a large tract of Chili was similarly shaken, a permanent rise of 2 ft. following the former earthquake, and a rise 8 ft. the latter.

The earthquake which took place at Cutch in 1819 is perhaps in some respects yet more remarkable. In this instance, phenomena of subsidence, as well as phenomena of upheaval, were witnessed. The estuary of the Indus, which had long been closed to navigation—being, in fact, only a foot deep at ebb-tide, and never more than 6 ft. at flood—was deepened in parts to more than 18 ft. at low water. The fort and village of Sindree were submerged, only the tops of houses and walls being visible above the water. But although this earthquake seemed thus to have a land-destroying, instead of a land-creating effect, yet the instances of upheaval were, even in this case, far more remarkable than those of depression. "Immediately after the shock," says Sir Charles Lyell, "the inhabitants of Sindree saw at a distance of five miles and a half from their village a long elevated mound, where previously there had been a low and

perfectly level plain. To this uplifted tract they gave the name of Ullah-Bund, or the "Mound of God," to distinguish it from several artificial dams previously thrown across the eastern arm of the Indus. It has been ascertained," he adds, "that this new-raised country is upwards of 50 miles in length from east to west, running parallel to the line of subsidence which caused the ground around Sindree to be flooded. The breadth of the elevation is conjectured to be in some parts 16 miles, and its greatest ascertained height above the original level of the delta is 10 ft.—an elevation which appears to the eye to be very uniform throughout."

COMPUTATION OF EFFECT OF GRADIENTS.*

By HERMAN HAUPT, C. E.

When the maximum load of the same engine on any two different inclinations has been determined by experiment, the data thus furnished will suffice to calculate the load on any other inclination, the load on a level, the angle of friction at which a train will descend by gravity, the tractive power per ton of load required on a level, and the number of pounds adhesion for each ton of load.

Let R = resistance of the train on a level, which is equal to the power of the engine.
W = gross weight of train on a level.
W^1 = weight of train on grade a.
W^2 = weight of train on grade b.

It is proper to assume that the power required to move a train and the resistance, which is equal to it, will be in proportion to the gross weight.

The force of gravity on any inclination is in proportion to the height of the plane divided by its length, or as the rise per mile divided by 5280.

The resistance of the train W^1 being in proportion to its weight, will be expressed by $\frac{W^1}{W}R$.

And the resistance of W^2 by $\frac{W^2}{W}R$.

The gravity of the train W^1 on the grade $a = \frac{W^1 a}{5280}$

and of the train W^2 on the grade

$$b = \frac{W^2 b}{5280}.$$

If the engine is supposed to be loaded to the limit of its capacity on each gradient, then the power exerted must be the same as on a level and

$$\frac{W^1}{W}R + \frac{W^1 a}{5280} = R.$$

$$\frac{W^2}{W}R + \frac{W^2 b}{5280} = R \text{ and consequently}$$

$$\frac{W^1}{W}R + \frac{W^1 a}{5280} = \frac{W^2}{W}R + \frac{W^2 b}{5280}.$$

From which the value of R in terms of W W^1 and W^2 is found.

$$R = W\frac{W^2 b - W^1 a}{5280\,(W^1 - W^2)}$$

Take now the former equation

$$R = \frac{W^1}{W}R + \frac{W^1 a}{5280}$$

from which a second value of R is obtained $= \frac{W W^1 a}{5280\,(W - W^1)}$.

Placing these two values of R equal to each other, there results

$$\frac{W^1 a}{W - W^1} = \frac{W^2 b - W^1 a}{W^1 - W^2}$$

By substituting in the equation the values of W^1 W^2 a and b, as determined by observation, the values of W, or the gross load on a level can be ascertained.

By substituting the values of W, W^1, W^2, a and b, the value of R on the power exerted by the engine is obtained.

By dividing this power in pounds by the gross load on a level, the tractile power per ton is determined.

As the power of an engine is always sufficient to slip the wheels on a dry rail, the adhesion is equal to the actual power exerted in moving the train, and, divided by the weight on drives, gives the proportion between adhesion and weight.

The angle of friction can be found when the tractive power per ton of 2000 lbs. on a level (T) has been determined by the equation.

Angle of friction expressed in feet per mile $= \frac{T \times 5280}{2000}$.

It has been customary for engineers to

* From a paper read before the American Philosophical Society.

consider the angle of friction as 16 to 18 feet per mile, the tractive power per ton on a level 8 pounds, and the adhesion one-eighth the weight upon the drives; but to obtain reliable data from the actual operation of roads running full trains, a letter was addressed to A. J. Cassatt, General Superintendent of the Penna. Railroad, who furnished the following data:

A standard 10 wheel freight engine with 3 pairs of $4\frac{1}{2}$ feet drivers with average water and coal, weighs....	75,500 lbs.
Weight on drivers	53,000 lbs.
Weight of tender with coal and water	50,000 lbs.
Such an engine will haul on a moderately straight and level road 50 loaded cars of 40,000 lbs. each Gross load	1,062 tons.
On a grade of 10 feet to the mile, 43 cars	922 "
On a grade of 26 feet to the mile, 35 cars	762 "
On a grade of $52\frac{8}{10}$ feet to the mile, 17 cars	402 "
On a grade of 96 feet to the mile, 11 cars...........................	282 "

And the engine would work easier with 50 cars on the level than in either of the other cases, and with most difficulty in the last.

Herman J. Lombaert, Esq., Vice-President and former General Superintendent of Pennsylvania Railroad, gives as a full average load for actual work in the usual conditions of the rail.

	Tons.
Load on $52\frac{8}{10}$ ft. grade, 16 cars. Gross load of engine..................................	382
Load on 10 ft. grade, 40 cars. Gross load of engine..................................	862

As it is proper to allow a margin for unfavorable condition of rails, the calculations will be made on the data furnished by H. J. Lombaert.

Substituting the values of a, b, W^1, W^2, which are 10, $52\frac{8}{10}$, 382 and 862, the value of W, or the gross load on a level, is found to be 1210 tons.

The value of R, or the tractive power on a level, is 11,160 lbs., or $9\frac{2}{10}$ lbs. per ton.

The angle of friction is

$$\frac{9.2 \times 5280}{2000} = 24.28 \text{ feet per mile.}$$

The adhesion is $\frac{11,160}{53,000}$ or nearly one-fifth of weight on drives.

From the data thus obtained a simple formula may be found to determine the load of the engine on any given inclination, a.

Let P = tractile power of engine on a level = 11,160 lbs.
a = feet per mile of inclination.
W^1 = weight of train on incline a, including engine and tender.

Then $W^1 \times 9.2$ = power required to move W^1 on level.

And $W^1 \frac{a}{5280}$ = gravity on incline a, in tons or $W^1 \frac{2000}{5280} a$ in pounds.

$9.2\ W^1 + \frac{2000}{5280} W^1 a$ = power of engine = 11,160 lbs.

$$\text{Or } W^1 = \frac{11,160}{9\ 2 \times .38\ a}$$

If a be supposed equal to 48.56, or twice the angle of friction, the load would be 404 tons nearly, or one-third the load on a level.

On a grade of 30 feet the load would be 541 tons. The grade that would require double the power of a grade of 30 feet would be $84\frac{1}{2}$ feet.

If the gross load of a train on a grade of 30 feet be 541 tons, the engine and tender being 63 tons, the cars and contents will weigh 478 tons, or if 18,000 lbs. be allowed for each car and 22,000 lbs. for load, the number of cars will be 27, and the net load 297 tons, weight of cars 243 tons.

If the return cars shall be only one-fourth loaded, which is probably a full proportion for the Shenandoah Valley extension, the gross weight of the trains would be 380 tons.

The inclination that would employ the full power of the engine in hauling 380 tons, would be 53 feet.

The inclination that would employ the full power of an assistant engine in hauling a gross load of 380 tons, would be 130 feet, but allowance must be made for the weight of the assistant engine.

MANY of the Japanese students who came to the United States last fall, having acquired the ordinary English branches, are now seeking the technical schools. They desire to become familiar with the methods of American engineering.

A METEOROLOGICAL Observatory is to be put up on Broadway.

ON THE HORSE POWER OF STEAM ENGINES AND BOILERS, AND SOME FACTS CONNECTED WITH THE EXPANSION OF STEAM.*

By EDWARD BROWN.

An actual horse-power, as is well known, is 33,000 lbs. raised 1 ft. high per minute. The application of this test to engines and boilers is the subject of this paper.

It has been, and still is, a common custom with steam engine builders, to specify in the contract of sale that the engine and boiler are of a certain size and horse power. That the machines come up to the contract in size is easily determined by measurement, but the actual horse power developed by a steam boiler is a subject upon which the seller and buyer may differ materially.

It is useless for one to attempt to make a standard rule for the horse power of an engine from the size of the cylinder. An engine 10 $\times$ 24 in. will work from 20 to 100-horse power, according to the pressure of steam and speed of the piston. The seller might designate whatever power he pleased within these limits ; it would be very little guide to the purchaser.

The case is, however, different when we come to estimate the horse power of an engine and boiler sold as a unit. There will be no question among engineers that here the horse power, according to common custom and practice, is the power exerted upon the piston, measured by the area of ths indicator diagram. If the machine will perform that work steadily, from week to week, such is its actual horse power.

Let us now examine the means of ascertaining the horse power of a steam boiler, sold, we will say, for 100-horse power, but failing to come up to the expectation of the purchaser. This is a practical question, and one not unfrequently occurring. Especially is it liable to occur with boilers of the non-explosive patterns, recently introduced. The makers are endeavoring to supply, and the purchasers to obtain, a perfectly safe boiler, of the same horse power and at the same price as those of the usual standard forms.

* A paper read before the Franklin Institute.

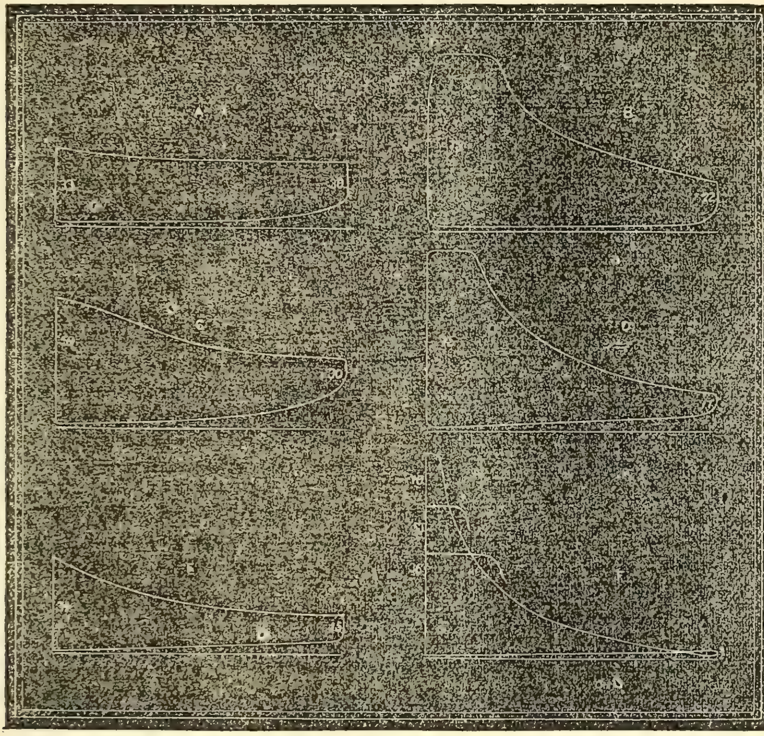
Several cases of this character having recently come under my observation, I will give you the course pursued in one of them to ascertain the horse power of the boiler.

The boilers replaced some old worn out boilers which were removed. They supplied steam to a cylinder 16 in. by 4 ft., speeded for about 50 revolutions. The boilers were fired to the best ability of the fireman, and steam being maintained at 40 revolutions, the cards A were taken, showing no expansion and $55\frac{1}{2}$-horse power. It was justly objected by the Boiler Company that this was an extravagant use of the steam, and not a fair test of the horse power of the boiler. A Tremper cut-off was then fixed on the back of the steam chest, and a trial made a few days afterwards. The steam chest was small, and the space between the cut-off and D valve not over $\frac{1}{10}$ the size of the cylinder. The card marked B was then taken, showing a cut-off at a little under $\frac{1}{4}$ from the commencement of the stroke, and 68-horse power with 33 revolutions. It is a very fair expansion card, the initial pressure being 73 lbs. Though not quite equal to a Corliss, it would be little behind it in economy. The gain in power resulting from the change from full stroke to $\frac{1}{4}$ cut-off is $12\frac{1}{2}$-horse, or 23 per cent., due to the expansion of the steam. But as there was less back pressure in the latter than in the former trial, we have an actual gain of 30 per cent. in the working of the engine. The engine exhausted into a feed-water heater.

Now notice the diagram C. This was taken with more boiler power, 3 being used instead of 2, as in the trial just described. The expansion curve here is formed entirely by the higher speed of the engine (53 revolutions) and the smallness of the port. The indicated H. P. was 89, and that developed by the Tremper cut-off, marked D, was 100 H. P. Here we have a gain of 12 per cent. only, due to the cut-off and expansion thereby, and a gain of 20 per cent. in the working of the engine; 12 per cent. from 23 per cent. leaves 11 per cent. gain, due to the wire

drawing of the steam, as in card C, over that used in the first trial, as shown by card A.

This result tends to prove that it matters little in practice whether the *expansion curve is formed* by the wire drawing through the port and the speed of the piston, or in the usual cut-off manner and low speed; and for this reason, that the action of the steam after it passes the port is almost instantaneous in comparison with the motion of the piston. The cylinder was well covered, though the steam pipe was not; had it been covered, and the cut-off valves close at each end of the cylinder, a little better result would have been obtained. The gain of 23 per cent. here obtained corresponds closely with the experiments of Mr. Isherwood, who gives 26 per cent. as the gain by suppressing during the last $\frac{3}{4}$ of the stroke, and using saturated steam. His experiments also go to show that about 16 out of this 26 per cent. is gained by suppressing during the last $\frac{1}{4}$ of the stroke.



When we consider the vast disproportion between the power which should be gained by cutting off at $\frac{1}{4}$ stroke, theoretically, and that resulting from practice, we may well doubt, as some engineers have done, if there is any gain in the expansion of steam *per se;* and conclude that the gain is due more to the application of the power at the commencement of the stroke, and the complete utilization o it before the termination. An experiment dispelled this supposition. During the dinner hour, when the engine was running the shafting only, the work being therefore constant, diagrams were taken at a speed of 48 revolutions. Four were taken at full stroke, marked E, and three were taken at short cut-off, as shown at F; the average pressure of cards E was 16.3 lbs., and of cards F 16.4 lbs, sufficiently near to be called identically the same. The experiment was carefully made, with the indicator just cleaned and oiled, and the calculated power was 38-horse power. In theory, a pressure of 50 lbs. through any part of the stroke would be as effectual as the same pressure through any other part of the stroke, taking no account of momentum. If we take this into consideration, the natural conclusion would be that a preponderating

power at the commencement of the stroke, or, in other words, the proper application of the power at the right time would be more effectual than an even power continued to the end of the stroke. Consequently, the cut-off cards should be smaller, but such was not the case; clearly showing that the gain in power in the previous trials was due to expansion. Of course, the equality of the two cards, E and F, only refers to this particular engine; it is quite possible that if F, only refers to this particular engine; it is quite possible that if the experiment was made at 150 revolutions instead of 48, the cut-off cards would be found the smallest. In a trial of this kind the indicator should be changed to each end of the cylinder. The fixing of it in the centre, though frequently adopted for convenience, is not sufficiently accurate.

The bearing these facts have upon the question before us is this, that whilst the horse-power of a boiler depends somewhat upon the engine it supplies, still it is only to a limited extent. That a three-port D valve engine, in good order, and cutting off at less than $\frac{1}{4}$ from the termination of the stroke, is realizing within 12 per cent. of the power. And even granting that it may be 20 per cent. under what is obtained in the best cut-off engines, a boiler should be able to give out that amount extra in a trial of ten hours, with good coal and careful firing.

Again, purchasers of steam boilers look at the question in a practical way; they do not understand the fine point, as to how much power the evaporation of so much water should produce; they want the power put through their own engine, and as three-quarters of all the steam-engines in use are plain slide valve, it is but reasonable to expect that every boiler sold for a certain horse power, shall be able to put that power through a plain slide valve engine, of proper capacity, in good order, and suppressing steam more than $\frac{1}{4}$ of the stroke.

Let us now consider the test by the evaporation of water. A 100-horse boiler may be sold to supply a 50-horse engine, the other 50-horse being required for heating purposes; or the boiler may be needed entirely for heating purposes. Here we must decide by the evaporation, and if the purchaser has not had the foresight to specify the amount, what shall be the test?

We take the old nominal horse power, and the evaporation of 1 cubic ft. of water is the test. We come down to the theoretical horse power, and 920 in. or 33 lbs. is the test. That is to say: theoretically, if you have a cylinder 1 sq. ft. area and 1,728 ft. high, and evaporate 1 cubic ft. of water within that cylinder in an hour and then condense the steam, it will give a force of 1.88-horse power.

I find on reference to Mr. Isherwood's experiments, that he obtained occasionally, 1-horse power from the evaporation of 29 lbs. of water, 4 lbs. less than the theoretical amount; this can only be accomplished by expansion. With superheated steam he obtained 1-horse power from 20 lbs. of water and an early cut-off. Modern practice has done better than this with the compound engine.

On the other hand, the steam may be overcharged with watery particles, and so show a high evaporation with little power; I have seen $\frac{9}{10}$ of a cubic foot required to produce a horse power in a very fair engine, cutting off at the last quarter. So we see that the range is from less than half a cubic foot to $\frac{9}{10}$ of a foot; the average for good engines being about 40 lbs. It is quite safe to assume that the evaporation of 1 ft. of water is abundance for a horse power, provided the consumption of coal be taken into account; for a small boiler with good draught, burning much coal, will give out as much power as a larger boiler burning less coal. Therefore, the commercial value of a steam boiler, estimated by the horse power, depends upon its ability to evaporate a given amount of water into dry steam, on a basis of a certain amount of coal, say, about 8 lbs. The conclusion arrived at in reference to this subject would be, that neither the test by the engine nor by evaporation is a positive test. By the engine test, the efficiency of the engine is always liable to be called in question. The steam pipe may be long and contracted, and the pipe and cylinder uncovered, and a large back pressure for which allowance must be made. The boiler may also be forced for a trial of 10 hours, and more coal burnt than usual.

And by the evaporation test it will be found that some boilers are notorious for lifting water; that is, carrying it over

bodily. Exceptional cases will always occur in which either test is unsatisfactory; then the only way is to combine the two methods.

It is desirable that the Franklin Institute should establish some standard generally acceptable among engine builders, so that the mill owner, in the purchase of a boiler of a certain horse power, may expect a definite quantity.

Until such is established, it will be for the interest of makers and purchasers of steam power to specify the test by which the power is to be measured.

THE POLLUTION OF RIVERS.

From "The Engineer."

In one form or another we have had a Royal Commission on the Pollution of Rivers for the space of 6 years. Rivers are still polluted, the Royal Commission still report, and the Commissioners are going to report still further. Former recommendations are reiterated, and measures declared urgent years ago are pronounced urgent now. Blue books fall heavily around us, but the rivers are still noisome, and farmers fail to recognize the value of sewage. The A B C Company are yet alive, and promise to astonish the world with their results, which they certainly will do if they succeed. Towards that issue the Company have our best wishes, and we do not see how the Metropolitan Board could have refused the offer of the Native Guano Company in regard to Crossness. Mr. Hope is experimenting at Romford, Exeter is availing itself of his experience, and the governmental authorities are all confident in recommending the agricultural use of sewage. Yet the ball does not roll well for all that. The Metropolis Sewage and Essex Reclamation Company are simply doing nothing but hold fast to their concession, and all the northern sewage of the metropolis falls into the Thames. Above bridge things look very dark. A Private Bill Committee of the House of Commons have approved a bill granting Richmond the privilege of discharging its sewage into the Thames for 3 years longer, and the Thames Conservators are almost in despair. The Royal Sanitary Commission has boldly grappled with the mass of permissive and disjointed statutes affecting the subject of its inquiry, and it is certain that if the land is to be clean we must have a new broom for the purpose. Lord Robert Montagu differs from his colleagues on the Royal Sanitary Commission as to the machinery of Government, but is deeply impressed with the utter feebleness of our present system. Parliament itself seems faint-hearted, and the apathy of the agricultural interest acts as a dead weight. Let once the value of the sewage be apprehended by the farmer, and the main difficulty is at an end. Accompanying this there should be a conviction on the part of the public that sewage is in every sense as safe as ordinary manure, and of the two less offensive. But the fact is, that neither the farmer nor the public generally is satisfied as to the merits of sewage irrigation, and a host of prejudices require to be swept away before any great progress can be made in the desired direction. It ought not to be needful for a town to ask for land whereon to utilize its sewage. The farmers ought to come to the towns to ask for the sewage wherewith to fertilize their fields. Instead of seeing how much sewage can be used on a given area, it ought rather to be an object to see how large an area can be fertilized with a given quantity of sewage. But from the practical exposition of these principles we seem almost as far off now as we were 10 years ago.

The present report of the River Pollution Commissioners deals mainly with the pollution arising from the woollen manufacture and processes connected therewith. The pollution of the river Aire is said to begin at Skipton, where silk and cotton spinning and pasteboard manufactures are carried on. Soon after leaving this point the river (including its tributaries) has to run the gauntlet of several towns, extending from Bradley to Headingley, and including Bradford. Situated in this area there are no less than 1,311 cloth and woollen factories, 1 silk mill, 1 flax mill, 7 paper mills, 26 tanneries, 13 chemical works, 8 grease-extracting works, and 4 glue factories, the refuse of which pours

into the stream, together with the sewage of more than a quarter of a million of people. Some of the establishments are gigantic, and Saltaire is among them. This one establishment alone uses in the course of a year 320,000 lbs. weight of logwood and similar dye wares, 15,000 lbs. of chloride of lime, ammonia, and oil of vitriol, 40 to 50 tons of Gallipoli oil, 700,000 lbs. of soap, 40,000 lbs. of alkali, and 14,000 tons of coal. At Keighley, above Saltaire, the bed of the tributary river Worth has been raised 5 ft. or 6 ft. in the space of 40 years by the quantity of ashes and rubbish thrown in by manufacturers and others.

Mr. Laycock, a wool comber on the Worth, just below Keighley, says: "Formerly trout were very plentiful in the stream, but now no living thing can exist except rats, which feed on dead carcases of animals thrown in." We might enlarge the catalogue of the factories, mills, "works," and sewers which pollute the Aire, either directly or by means of its tributaries, down to its junction with the Calder, about 10 miles below Leeds; but it may suffice to say that the inhabitants of Castleford, contiguous to the junction, "complain of the stench and filth brought down to them by both rivers." The Commissioners state that at the weir, beside the Aire and Calder corn mill, not only the water but the foam upon it was black at the time of their inspection, and "the miller and his men" complained of the frequent nausea which they suffered from the odious stench to which they were continuously subjected, Yet an analysis of the water is said to show that "the pollution of the combined streams Aire and Calder is much less than that of the chief polluted rivers in Lancashire."

It might be feared that to interdict this pollution of the stream would be injurious to the manufacturing interest. But the fact is that this interest suffers severely through the pollution of the water. It is useless for one manufacturer to turn his refuse away from the river unless others are made to do the same. Hence all pollute the river, while each desires that the water should be pure. A law which should compel all parties to respect the stream would be a benefit to all, except in those few cases where the manufacturers have an independent water supply, or in those instances where clean or pure water is not required. "On the whole," say the Commissioners, "it is apparent that the foul condition of these rivers is really one of the heaviest taxes which manufacturing industry has to bear." Speaking in reference to the town of Leeds, the Commissioners remark that "20 years ago the river was comparatively clean; it is now a black and greatly polluted stream." The corporation "have no jurisdiction over the Aire, which flows through the centre of the town," but they "suggest, as the best means of avoiding pollution for the future, that all local authorities and manufacturers should be compelled to utilize their sewage and liquid refuse, and to filter, deodorize, and precipitate it before allowing it to flow into riv rs or their tributaries." Leeds seems to experience the miseries of a twofold difficulty. It pollutes the river with 6,000 water-closets, and poisons its streets with 10,000 cesspools. The latter are "cleansed periodically under the direction of the Sanitary Committee of the corporation," with a clear loss of £5,500 a year, and the creation of a stench which from 10 P. M. till 4 A. M. is "something fearful." In addition to the sewage proper there is the waste from "a very large number of dyeworks, woollen factories, tan-yards, and chemical works." Thus a great manufacturing town finds itself perfectly helpless in the midst of a mass of costly pollution, the presence of which it sincerely regrets, while adding its own share on a large scale to the general evil.

The basin of the Calder is next explored. The head waters of this river are remarkably pure, but town after town pollutes the tributaries on their way to the main stream, and the river itself as it proceeds downwards to the Aire. Todmorden, engaged in the cotton manufacture, with 12,000 inhabitants, contributes sewage, together with liquid refuse from manufactories, chemical works, gas works, dye works, and mines. The river bed near that town has been raised by making it the receptacle of all kinds of solid refuse, including scoria from iron foundries, slag, cinders, and road sweepings. Todmorden suffers severely from floods, which are greatly aggravated by this improper treatment of the river. Below Todmorden the Calder receives the water of the Hebble, bringing down with it "a very filthy contribution" from the town of Halifax,

where there are 65,000 inhabitants, chiefly engaged in the woollen manufacture. Huddersfield, with 70,000 inhabitants, pollutes the Colne, until the condition of the river and canals is such as to be "a source of ill-heath and discomfort" to the inhabitants of the town. The Commissioners say: "Films of tar were floating on the surface of the foul stream when we saw it." Six miles lower down the Calder takes in a stream which brings down the drainage of Batley and Dewsbury. "The stream is polluted in the usual way by liquid drainage, and encumbered by all sorts of solid refuse." Wakefield, with its 26,000 inhabitants, is the lowest town on the Calder, making the last considerable addition to its pollutions. The river is here said to be in "a miserable plight," fouled by many kinds of liquid refuse, and very much discolored. It furnishes a sort of Calder ink, wherewith Mr. Charles Clay, an agricultural implement maker, has indited a memorandum, produced in the report in the form of a *fac-simile*, and specifying as follows: "Dedicated without permission to the Local Board of Health, Wakefield. This memorandum written with water taken from the point of junction this day between the river Calder and the town sewer. Could the odor only accompany this sheet also, it would add much to the interest of this memorandum." The Royal Commission enjoyed a trip on the river in the steam yacht of the Aire and Calder Navigation Company, kindly placed at ther disposal for the purpose. Embarking at Wakefield, the Commissioners found the Calder below the town to be "turbid, and of a dark brown color; an oily film floating on the surface, and the water emitted a mixed odor of sewage and gas tar." That which follows is still more horrible: "At a point somewhat below this, about a mile below the main sewer outlet, the water supply of Wakefield is taken from the river." Let us imagine London taking its water supply from the Thames a mile below the outfall sewers at Barking and Crossness! Yet at the point of junction between the Aire and Calder the Aire was found to be "polluted to more than twice the extent of the Calder, by both dissolved and suspended matters." Steaming up the Aire towards Leeds, the Commissioners landed at Woodlesford, where a paper manufacturer showed them a yellow-tinted paper utterly spoiled by the gaseous emanations of the river.

Such is the lamentable condition of rivers, some of which only a generation ago were either pure or comparatively so. The Commissioners are confident that these evils admit of a remedy, in which the principle of sewage irrigation will play an important part, filtration being employed in certain cases.

THE PROGRESS OF THE IRON AND STEEL INDUSTRIES IN FOREIGN COUNTRIES.*

From "The Journal of Iron and Steel Institute."

As an attempt to supply, in some measure at least, a long acknowledged deficiency in our technical information, viz., that of knowing what is being done in the different branches of the iron and steel manufactures abroad, the Council of the Institute have requested the foreign secretary to draw up, in the form of a quarterly report, a brief summary of such information as can be obtained, connected, more or less directly or indirectly, with the advances made in these important industries in other countries.

This being the first occasion offered for carrying into effect the wishes of the Council, it may not be considered out of place, to premise by devoting a few introductory remarks to the present relative positions of the British and foreign iron and steel industries, considered from a technical point of view. One of the great features characteristic of the age in which we live, is the active competition, or intense commercial rivalry, which has developed itself in all countries, and in all branches of manufactures, owing to the rapid strides almost daily made in advance, due, mainly, to the more and more extended application of scientific principles to practical routine. Probably, in no single branch of industry is this competi-

*Abstract of Quarterly Report on the Progress of the Iron and Steel Industries in Foreign Countries, by David Forbes, F. R. S.

tion more apparent than in iron and steel making, and as one result of it, the British ironmaster, who, for the last half century has occupied a position, universally conceded to him,—that of being at the head of the iron and steel manufactures of the world, now sees that the development of these industries abroad, more especially on the Continent, has, in late years, raised countries, far less favored by nature in these respects, to the rank of formidable competitors in a manufacturing field, which, previously, he had been accustomed to regard as peculiarly his own.

It is no doubt perfectly true, that the British iron trade still continues far ahead of that of any other country in the world, and, also, as regards the annual turn out of this important metal, that Great Britain still furnishes nearly, if not quite as large a quantity, as the united production of all the other iron-making countries put together; still, the statistics of the trade will show plainly that foreign countries have in late years rapidly been gaining ground upon us, or rather it should be said, have been lessening the previous great disproportion between their and our own total annual make of iron, and further indicate that, at least in some few branches of the manufacture, they have even gone so far ahead, as to rival and even excel us, in regard to quality and cheapness of production.

It becomes, therefore, a question, both of importance, as well as of interest, to inquire into the why and wherefore of this result, and to scrutinize the reasons which have already been advanced in its explanation. The assertion, which has been made, that the rapid development of the foreign iron trade is to be attributed "to the greater improvements made in the manufacture of iron in France, Belgium, Germany, and Austria," only requires a little consideration, to be proved entirely destitute of any foundation, and to show that it is no vain boast on our part, to declare, that most if not all of the greatest improvements, or, what may be termed revolutions, which have taken place in the modern history of the iron and steel manufacture, have been effected by purely British discoveries, and it is sufficient, amongst others, to mention the substitution of pit coal for charcoal, by Dudley; the puddling process and rolling mills of Cort; the hot blast introduced by Neilson; and, in regard to steel, the method of making cementation or blister steel, and crucible cast steel, along with the Bessemer process, to prove how much our continental rivals have been indebted to us for even the most essential elements of their own success, and if we inquire into this subject further, it will be found that we not only provided them with these inventions, but that in many instances we actually lent them the very talent which transplanted the modern (English) system of iron and steel making on to their soil, to grow up afterwards to its present dimensions; as may be seen, for example, amongst many others, in the case of Creusot, the largest iron works in France, which owes its existence to Wilkinson, in 1782, whilst the modern iron industry of Belgium may be said to date from the establishment of John Cockerell's works at Seraing, in 1817.

Next, as regards the supply of the raw materials the advantage is decidedly on our side; for, both in France and Belgium, a very considerable percentage of the total consumption of iron ores is imported from other countries from which the cost of transport is much higher than with ourselves; whilst with respect to fuel, it is admitted that in most, if not in all cases, our coal is not only cheaper, but, as a rule, much superior in quality to that made use of in the iron districts of the Continent. In fact, the very cheapness of our coal is the reason why it is commonly employed in the most wasteful manner; so much so, indeed, that the same amount of power or useful effect of the combustible often costs more in England, notwithstanding the cheapness of fuel, than on the Continent, where its greater value has compelled the most economical systems for its more perfect utilization to be carefully studied and practised.

In the question as to comparative cheapness of labor, the iron-master on the Continent has, however, a decided advantage over us; yet, in considering it, it must be remembered that the English workman is physically stronger and, *cæteris paribus*, capable of doing more actual work in the same number of hours than the foreigner; for which reason the advantage in this respect is not so great as would be represented by a mere compari-

son of the money actually paid in days' wages, but is only to be correctly estimated when piece-work rates are taken into consideration. The English workman, generally altogether uneducated, and with comparatively little intelligence, is, as a rule, a mere machine—a very perfect one it is true, if he be allowed much of his own way, and be permitted to follow, without deviation to right or left, the groove in which he was originally started; but otherwise, he is, in too many instances, obstinacy itself, and would rather strike work than listen to anything in the form of changes or improvements. On the other hand, the Belgian, French, or German workman is much better educated, and consequently more intelligent, is willing to be reasoned with and to accept improvements, and, being much more frugal in his mode of living, is in reality better off on much less wages than workmen receive in this country; besides which, there is on the Continent, as a rule, a much better feeling between man and master than in this country, and this appears to be the principal reason why strikes so very rarely occur amongst them.

If we compare the general character of the machinery made use of in iron works, the foreign will usually be found deficient in that massive appearance so characteristic of ours; and the English engineer would probably, at least in many instances, denounce it as far too light and flimsy. This is due to the practice of foreign engineers to employ no more substance in the construction of their machinery than is strictly necessary, according to careful calculations of the force required and strength of the materials used. Although sometimes they, no doubt, leave too little margin for defects in material or workmanship, it does not, as a rule, appear that they have more breakdowns than usual in English works, where much more massive machinery is seen; and this suggests the idea that mere weight of metal may often be employed with us to insure strength in the place of excellence of design.

The general arrangement, or laying out of the iron-works abroad, is, with few exceptions, superior to ours, which, as a rule, may be said to have built themselves up from a patchwork of additions, made from time to time as the necessity for enlarging has occurred; with us, it is but rarely seen that any systematic plan has been at all followed, and even when new works are erected they are too often but magnified copies of the old ones, already more or less antiquated, with most, if not all, their imperfections. The same remarks apply, in too many instances, to the management also, which is seldom characterized by an equal amount of either the intelligence, system, or economy usually met with on the Continent; whilst, until more recently, it cannot but be admitted that both our masters and our men have shown themselves equally loath to adopt or encourage improvements until absolutely forced to do so by pressure from without.

For the very reason that capital is both dearer and less easily obtained than in England, far greater care is devoted to its judicious expenditure on the Continent, and the construction or management of works is not left in the hands of the too often all but uneducated so-called practical man, but intrusted to those who, by a regular course of study, scientific as well as practical, have qualified themselves for such duties, so that their establishments are, as a rule, found to be much better arranged than ours, all the operations following one another so as to entail the least possible unnecessary labor and expense; and we do not see, as sometimes here, whole acres of ground around the iron-works, literally covered with old iron in all forms, representing so much idle capital and loss of interest; for on the Continent, where no such extravagance could be afforded, it is only by the strictest rules of administrative economy, the attention paid to turning over the capital as quickly as possible, and the immediate adoption of every recent improvement, that the ironmaster in Belgium and France can hold his own, and be enabled to enter into competition with ourselves, who are so much favored by nature in respect to iron-making.

From what has already been said, it will be perceived that the secret of the continental success in the iron and steel manufacture, does not lie in any great discoveries or inventions which they have made, but that next after the supply of cheaper and more intelligent labor, which they can command, it is mainly dependent upon the careful and scientific

attention paid to the details of each department, by which everything is reduced to sound practical rules; whilst we, on the contrary, have, at least until lately, been too much accustomed to treat our furnaces, forges, and in fact everything connected with the manufacture, in a sort of wholesale rule-of-thumb manner, leaving the details to take care of themselves, and relying mainly upon our great command of capital and unrivalled local resources, without much troubling ourselves about what the rest of the world may be doing in the same direction.

As before mentioned, it was the great British discoveries in the manufacture of iron and steel which smoothed the road for the foreign ironmaster, armed as it were with the weapons with which we ourselves have provided him, to enter into the field of competition with us in these industries; and since then, he has not neglected to avail himself of the full benefits of our often very costly experiences, by making himself acquainted with and adopting all our different improvements as fast as they appear, often improving upon them in his turn, and by keeping himself fully posted up in all matters connected with these manufactures both here and elsewhere.

In this respect the foreigner is greatly assisted by the many and excellent journals and other publications which he possesses, specially devoted to mining and metallurgy, and is still further aided by the valuable reports constantly published by able men, sent out at the expense of their governments, mining schools, or other public institutions, for the express purpose of studying and reporting upon the improvements made, and the actual conditions of the various branches of such industries in other countries, with a view of obtaining information calculated to advance these industries in their own country.

The difficulties which any one in England, who may be interested in the manufacture of iron and steel, has to contend with, when seeking information as to what is going on in these industries even in his own country, not to mention foreign parts also, are not to be underrated; for to our shame must it be acknowledged, that we have not a single periodical in Great Britain dedicated to the science or practice of mining and metallurgy, notwithstanding that in this branch of industry our interests are admittedly the greatest in the world ; and it seems as surprising as it is true, to think, that if we wish for information as to what is being done in these directions amongst ourselves, we have no resource but to refer to journals or works published in the German, French, or Swedish languages, or to attempt to acquire it *viva voce* on the spot.

As the space at command is necessarily limited, it would be quite impossibe, within the scope of such a report, to devote more than a comparatively very short notice to any one country, or department of the manufacture; for the object sought to be attained is not so much to communicate any lengthened description of the iron trade of any one country, or of any particular metallurgical process or machine, as to convey a somewhat general, but, as far as possible, correct impression of what is going on elsewhere, and to point out how, and where, more detailed information as to any particular improvement, or statement connected with this industry, may be obtained by those persons who may be more particularly interested in its study or application.

In order to do so, it is proposed to submit the principal foreign journals treating of applied science, or subjects directly or indirectly connected with the metallurgy of iron and steel, to a careful examination, in the order of their publication, so as to extract therefrom all such information as relates to these manufactures ; the substance of which will be communicated in the report, in notices longer or shorter in proportion as the importance of the subject appears to demand ; and attention is directed to the following list of foreign periodicals representative of the respective countries under which their titles are placed, which will be regularly submitted to such scrutiny :—

Austria—
- Oesterreichische Zeitschrift für Berg und Huettenwesen.
- Zeitschrift der Deutsch Oesterreichische Stahl Industrie.

Belgium—
- Recueil Spécial des Brevets d'Invention.
- Revue Universelle des Mines et Métallurgie.

France—
Annales des Mines.
Annales Forestières et Métallurgiques.
Bulletine de la Societé de l'Industrie Minerale.
Descriptions des Machines et Procédés pour lesquels des Brevets d'Invention ont été pris.

Germany—
Berg Geist.
Berg und Huettenmannische Zeitung.
Polytechnische Centralblatt.
Polytechnische Journal. (Dingler.)
Zeitschrift fur das Berg Huetten und Salinenwesen in dem Preussischen Staate.
Zeitschrift des Vereins Deutscher Ingenieurs.

Italy—
Bollettino Industriale del Regno d'Italia.
Giornale delle Arti e delle Industrie.
Il Politecnico.

North America—
Americal Journal of Science and Arts.
Bulletin of the American Iron and Steel Association.
Journal of the Franklin Institute.
United States Commissioner of Patents' Reports.

Norway—
Polyteknisk Tidsskrift.
Nyt Magazin for Naturvideuskaberne.

Spain—
Minera Revista.

Sweden—
Jern Kontorets Annaler.
Ingeniörs Foreningens Förhandlingar.

Commencing now with a review of the progress of the iron trade on the Continent, and elsewhere, in the alphabetical order of the names of the respective countries :—Austria, which, from its geographical position, has been one of those least affected by the lamentable war raging on the Continent, appears to have been steadily going ahead in respect to both the iron and steel manufactures. During the year 1869, the total production of iron, which, in 1845, only amounted to about 175,000 tons, had increased to 395,000 tons, and this increase was particularly remarkable in Bohemia, where, owing to the erection of various blast furnaces of larger and more modern construction, the make for 1870 is estimated at some two-and-half million centners, or above 123,000 English tons of pig iron for that province alone.

The latest return of the blast furnaces in Austria which we have come across is for 1867, in which year there was a total of 292, 210 of which were in blast ; against 295 returned as existing in the previous year, 1866, of which, however, only 195 were in operation.

In 1867, the total production from the mines is given at 13,284,356 centners, equal to about 620,710 English tons iron ore, and the yield of pig iron amounted to 5,712,552 centners, or 281,011 tons.

Up to the very commencement of the war between France and Germany, the annual production of iron in Belgium has continued rapidly and steadily increasing ; from a total of only 144,000 tons in 1850, it rose to 319,000 tons in 1860, and last year, 1869, it is returned at 863,000 tons, so that it has nearly tripled itself within the last ten years.

At the beginning of this year, 1870, every symptom showed itself that this great rate of increase would be fully maintained, since from the official statistics it appeared that during the first five months of this year the exportation of rails from Belgium amounted to 50,617 tons, against 41,895 tons in the corresponding period of 1869, whilst only 27,597 tons had been exported in the corresponding period of 1868.

During the last half of this year, however, this manufacture has been suffering more and more from the effects of the war, orders having rapidly fallen off; and it is in great measure due to the promptness with which the Belgian Government came to the assistance of the ironmasters, that they have been enabled, without making any very material reductions, to carry on their works in the face of the very adverse circumstances against which they had to contend.

In consequence of the war the export of rails from Belgium during the month of August, this year, declined to 7,132 tons, against 19,486 tons in August, 1869; and the returns of the total quantity of rails exported during the first eight months of 1870, show a marked decrease on those of the corresponding months of the previous year, being 93,889, against 103,746 tons in 1869. A reference, how-

ever, to the figures before mentioned, which represented the exportation for the first 5 months of 1870, will show that the entire falling off took place after the commencement of the war. The same remark applies to the importation of iron ores into Belgium, which in the month of August, 1870, only reached 38,357 tons, against 57,461 tons in August, 1869 ; although, owing to the very much larger quantity imported during the first half year 1870, than in the first half year 1869, the total importation for the first 8 months of 1870 amounted to 424,130 tons, or considerably more than in the corresponding period of 1869, during which it only reached 376,924 tons.

In France the total production of iron for the year 1869 is returned at 1,380,000 tons, and the prospects at the commencement of this year appeared most promising, and, in fact, most of the iron-works were kept extremely well occupied up to near the end of July. It will be seen, by a reference to the annexed figures, that the production both of cast and wrought iron during the first half year of 1870, exhibited a decided increase over those returned for the corresponding period in the preceding year :

	Cast Iron.	Wrought Iron.
1st half-year, 1870 ..	714,892 tons ..	510,528 tons
1st do. 1869 ..	699,749 " ..	497,328 "
Increase in .. 1870 ..	15,143 " ..	13,200 "

and the production of steel for the first half year, 1870, is estimated at—

Bessemer steel	25,360 tons.
Martin, and other steel	44,219 "
Total	69,579 "

The Custom House returns of iron ores imported into France during the first 5 months of this year, show 228,905 tons, of which quantity, 52,117 tons came from Belgium; 46,783 tons, from Germany; 41,580 tons, from Spain ; and 70,243 tons, from Algeria.

The effects of the war could not otherwise than prove most disastrous to the iron trade of France, and, of course, the ironworks of the Moselle group, from their close proximity to the frontier and seat of operations, were the first to feel these effects. In the beginning of August, the mineral workings of the Moselle had already been all but deserted, the forges and furnaces of Stiring and Ars been stopped, and many of the Longwy ironmasters had decided upon blowing out their furnaces ; on the other hand, the ironworks situated in the basin of the Loire had, up to the latest advices, continued in the greatest activity; all the works at Firming, St. Etienne, St. Chamond, Aissailly, and Rive de Gier, having turned their attention to the production of warlike materials,—cannons, balls, shells, armor-plate, etc.—whilst their workshops assisted in the production of small arms of all kinds.

In Germany, notwithstanding that in some few places, the effects of the war have given rise to an unprecedented activity in certain branches of the iron and steel manufacture, there cannot be much doubt but that, on the whole, these industries have suffered greatly, more especially by reason of the immense number of hands which have been drawn away from the mines and works for military service, so that it will most probably appear, when the statistical returns are made out, that the great annual rate of increased production, so well marked in late years, will not have continued in 1870 ; and it is not unlikely that the total production may not even reach the figure of the preceding year.

In 1845, the entire production of pig iron in the German Confederation (Zollverein), is stated not to have exceeded 180,000 tons. The discovery in 1850 of the so-called black band iron ores of Westphalia, and the development of the coal fields, gave at once an enormous impetus to the trade, so that in the years 1867 and 1868 the returns showed that the production had already risen to 1,032,000 and 1,181,344 tons respectively; whilst for 1869, which has not as yet been made known, it is anticipated that the amount will reach fully one-and-a-quarter million of tons.

According to the "Berg Geist" for 1870, p. 141, there were in the Zollverein in the year 1868, 1622 iron mines in operation, which employed 28,356 men, and yielded 72,687,372 centners, or 3,547,304 English tons of iron ore, and that during the same year the products from the smelting establishments were as follows:—

	Centners.	English Tons.
Pig iron	24,003,753....	1,181,344
Castings	5,336,618....	258,847
Wrought iron of all kinds	15,025,344....	739,470
Steel....................	2,456,736....	120,908

In the Zeitschrift f. d., Berg Huetten, u. Salinenwesen i. d. Preussischen Staate, Bd. 16, s. 209, attention is drawn to the production of Bessemer steel at the Konigshuette, in Upper Silesia, the pig iron being treated directly without re-smelting, and no spiegeleisen required, as a peculiar gray iron produced on the spot is found an excellent substitute; it is further stated that the ores of Upper Silesia are admirably adapted for the Bessemer process, and that this district can compete with any other in the manufacture of Bessemer steel. A paper by C. F. Durre, of Berlin, on the cause of the frequent irregularities in the working of the Upper Silesian charcoal and coke blast furnaces, and on the means of preventing or curing the same, will also be found in the "Berg und Huettenmannische Zeitung" for 1870, pp. 337 and 345, and as an example of how, on the Continent, means are taken for keeping the ironmaster well posted up as to all that goes on elsewhere, a report, made by Herr Nasse, one of the Prussian Government mining staff, published in the Zeitschr. f. Berg Huetten u. Salin. f. d. Preussischen Staate, Bd. 18, s. 1, gives a summary of the state of our wrought iron and cast steel manufactures in 1869, based upon data obtained by that gentleman, on a tour of inspection in England and Wales during that year.

The next country in alphabetical order is North America; and here we find, according to the very recent reports of the Secretary of the American Iron and Steel Association, that the iron trade of the United States, has increased at a very extraordinary rate during the last few years; the total production of anthracite pig having risen from 519,211 tons in 1860, to 971,150 tons in 1869; whilst at the same time the make from the bituminous coal furnaces has increased with equal rapidity, being, in 1869, 553,341 tons, or 63 per cent. more than 1868, 74 per cent. above 1867, and 105 per cent. above 1866. In 1854, it did not exceed 54,485 tons; since which time the average annual increase has been at the rate of 54½ per cent. The production of charcoal iron in 1869 is returned at 392,150 tons; of which quantity 38,000 tons were made in the New England States, 134,000 in the Middle States, 206,500 in the Western States, and 13,650 tons in the Southern States. The total production of pig iron of all kinds in the United States, for the year 1869, amounted to 1,916,641 tons; a figure which indicates that the make has more than doubled itself in a period of four years only. The production of railroad iron, in 1869, reached 593,586 tons,* against 189,818 tons in 1861, and as in the course of the year no less than 345,000 tons additional were imported, it follows that the total consumption in that year amounted to 938,586 tons; and it is estimated that, if the extension of the United States railway system continues at the same rate, it will require, during the next five years to come, an average supply of at least one million tons per year.

The produce of the rolling mills, other than rails, in 1869, was 642,420 tons, the principal items in this amount being 292,500 tons bar and rod; 36,320 tons sheet; 68,000 tons plate; 17,200 tons hoop; 146,400 tons spikes and nails; 72,000 tons axles, etc.; whilst 120,795 tons of these descriptions of iron were imported in the same year; which, consequently, makes a total of 763,215 tons as the entire consumption of wrought iron, other than rails, in the year 1869.

According to a statement made by Mr. Humphreys, at the American Institute Fair, Nov. 1st, the production of wrought iron in the United States, in 1869, was 550,000 tons; but that during that year no less than 600,000 tons of rails were rolled, more than one-half in Pennsylvania, the rest in New York, Troy, Rome, Syracuse, Elmira, and Buffalo; and, according to him, the most of these rails were of a superior quality to those imported.

Very little Bessemer pig iron is used in the United States: about three-fourths of the entire quantity used in making Bessemer steel being imported, and it is stated that the steel rails made in the United States cost almost, if not quite, as much as the price at which they can be imported from Europe, even after paying the duty. Mr. Humphrey estimates the quantity of steel made annually at Pittsburg at 20,000 tons, chiefly turned out of four establishments, and allows that it is not so uniform in quality as Sheffield steel. The Secretary of the American Iron and Steel Association in his report,

* No doubt a large proportion of this quantity consisted of re-rolled old rails.—(D. F.)

returns the total amount of Bessemer steel rails manufactured in the United States, in 1869, at 9,650 tons. It must be remembered that the ton in general use in the United States and other parts of North America is only 2,000, instead of 2,240 avoirdupois pounds.

In Norway, the iron trade has of late gradually fallen of, so as to have become all but extinguished. Within the last few years many of the principal iron-works have been stopped, so that of the fifteen blast furnaces in the southernmost district, there are at this moment probably not more than 5, if quite as many, in blast, and it is doubtful whether any of these could produce best charcoal Bessemer pig under £4 10s. per ton, a price which can hardly be expected to prove remunerative.

The chief cause of this decline is to be attributed to the daily increasing want of fuel in a country which possesses no coal, and in the greater cost and difficulty of obtaining sufficient charcoal, owing to the destruction of the forests, caused by the most improvident and really barbarous manner in which from times immemorial they have been dealt with, combined with the great development of the export timber trade of the country.

The great fall in price and demand for Norway charcoal bars, formerly in so high repute, especially in the North American market, and the United States all but prohibitory tariff, as well as still more recently the continental war, have all combined to hasten the ruin of the iron trade of this country.

The only steel now made in Norway is at the Naes Works, near Arendal, where crucible cast steel is made on some scale by the usual English process, both for home use as well as exportation, chiefly to Germany. The Bessemer process has not as yet been introduced into Norway, and some trials made with the Heaton process on pig iron made at the Eidsfoss Works, although to some degree satisfactory, were not considered sufficiently so, to warrant its adoption at that establishment.

With regard to the production and manufacture of iron in Russia, the information which we have been able to obtain has been extremely incomplete and vague. According to different writers, the total annual production of iron in the Russian empire varies from 200,000 to 350,000 tons; but most accounts agree in representing the iron trade in that country, if not actually declining, as nearly stationary, since the increased production in some few districts is about, or even more, than counterbalanced by the diminished yield in others, caused by a deficient supply of fuel, owing to the destruction of the forests.

Until very recently charcoal has been the only fuel employed in most parts of Russia for smelting iron ores. Recently, however, a new era has been inaugurated, by the utilization of certain previously little explored deposits of coal, for the making of iron on a much larger scale than hitherto, especially of the coal mines of Jekatarinoslaw, on the Kharkoff Azov line; in connection with which, very extensive works for iron-making and for the production of rails, are now in course of erection, by means of English capital, at Alexandrosski, near Mariupol, on the Sea of Azov.

Spain is a country in which it is extremely difficult to obtain reliable information on most subjects, and this is the case with regard to its iron and steel manufactures also ; it would appear, however, that the production of iron in this country, if not actually retrogressing, is, at any rate, far from advancing. Foreign iron appears to have, in a great measure, pushed the formerly so-esteemed Spanish product all but out, even of their own markets, and the attention which before was directed to iron-making, is now, in a great measure, turned to the extraction and exportation of the better qualities of Spanish iron ores to other countries, more especially to South Wales, France, and Belgium, a trade which is yearly increasing, particularly from the northern coast of Spain.

The latest statistics which we have come across are for 1867, in which year there were 245 iron mines, or concessions, in operation ; which employed 2,366 workmen, and afforded 2,544,807 metrical quintals, about 125,242 English tons, against 1,801,313 quintals, or 88,650 tons the year before, 1866.

The number of iron-works and forges in Spain, in 1867, is returned at 149 ; of which 102 were in operation, employing 4,886 workmen, and in that year also 23 blast furnaces, and 27 Catalan forges were in blast ; besides 26 blast furnaces

and 2 Catalan forges idle. The total production of iron and steel in Spain for the years 1866 and 1867 is given as follows:

	1867. Metrical Quintals.	English Tons.	1866. Quintals.	Tons.
Cast iron of all sorts	461,192	22,697	392,598	18,290
Wrought iron of all sorts	356,397	17,539	332,384	16,027
Steel	3,311	160	5,772	283

In Sweden, the subject of the future of the iron trade of the country is one which at this moment is attracting much attention, and, upon this question, opinions are divided as to whether the future iron and steel industry should be based upon the production of manufactured articles, as rails, tyres, etc., or should be confined to the exportation of raw and half-finished products, like iron ores, Bessemer pig iron, and Bessemer steel ingots—suitable for manufacturing purposes in England and elsewhere. In support of the first opinion, its advocates allege that Sweden, by means of the Bessemer process, and the importation of fuel from England, can compete with that country in the production of steel rails, tyres, etc., more especially for the Russian market. A good specimen of their arguments and calculations will be found in an article in the Stockholm "Aftonblad;" a translation of which appeared in "Engineering," August 12th, p. 171, where it will be seen that the case has been placed in rather too favorable a light, owing to several very essential elements in the calculations upon which the estimated cost of Bessemer pig and steel are based, such as the cost of fuel, freight, etc., being put down at figures considerably under the mark. The author of this report, (D. F.) holds with the supporters of the other side of the question, believing that Sweden will do better in confining herself to supplying the daily increasing demand for first-class iron ores and half-finished products, by exporting them to other countries, more particularly to England, where the cheapness of fuel and of capital can effect their further elaboration at a price much lower than it can be done for in Sweden. The increased facilities for transport, which will be afforded when railways become opened out into the immensely rich mineral districts of Central Sweden, and especially by the projected Fahlun and Krosskarr line will enable immense quantities of the purest iron ores, averaging some 60 per cent. of iron, to be shipped from the east coast of Sweden, so as to be delivered in England at about £1 per ton, and such a trade could not but prove greatly to the benefit of both countries.

Although Sweden possesses practically inexhaustible mines of the finest iron ores, the production of iron is altogether limited by the supply of charcoal, which can be obtained annually from the forests, which in most parts of the country have not only been treated in the most improvident manner, but also of late years have much diminished in area, by the large tracts which from time to time are cleared away and brought under cultivation; so that, at the same time, the annual supply of charcoal is not only becoming less and less, but its cost price is increasing in a similar ratio.

Another cause of the present depression of the Swedish iron trade is, that owing to the great improvements which in late years have been made in the manufacture of iron with coal, the charcoal-made iron, notwithstanding its undoubted superiority in quality, does not now hold the same increased value, when compared to the latter, as it formerly did; and from being only employed for exceptionally good requirements, is much less in demand at present.

This is beginning to be understood in Sweden, for although the majority of the Swedish ironmasters still continue in the old groove of charcoal hearth refining, more and more attention is being directed to Bessemer steel making, which, although hitherto confined to the three works of Högbo, Siljanfors, and Carlsdal, is now also in steady operation at Fagersta, whilst new Bessemer plant is in course of erection at Farsbacka, near Gefle, and further north at Iggesund; and similar works are also in contemplation at Swartnaes in Dalecarlia, and at Smedjebackan, where, for the last two years, the manufacture of rails from refined iron has been carried on without proving as yet a commercial success.

Very recently, some attention has been

directed to the manufacture of spiegeleisen, and one or two furnaces have, during the last year, been engaged in its production, it is said with success. As, however, the Swedish iron ores in general are seldom rich in manganese, it does not appear probable that this manufacture will develop to any great extent.

In conclusion, it may be mentioned that a very interesting series of specimens of the principal Swedish iron ores, and the products from their reduction, have, within the last month, been presented by the Swedish Iron Office at Stockholm to the Museum of the Royal School of Mines at Jermyn Street, and are well worth an examination by those interested in the metallurgy of iron.

EXAMPLES OF THE PERFORMANCE OF THE ELECTRO-MAGNETIC ENGINE.

By J. P. JOULE, D. C. L., F. R. S.

From "The Artizan."

Some experiments and conclusions I arrived at a quarter of a century ago, having been recently criticised, I have thought it might be useful to place the subject of work in connection with electro-magnetism in a different and I hope clearer form than that in which I have hitherto placed it. The numbers given below are derived from recent experiments.

Suppose an electro-magnetic engine to be furnished with fixed permanent steel magnets, and a bar of iron made to revolve between the poles of the steel magnets by reversing the current in its coil of wire. Such an arrangement is, perhaps, the most efficient, as it is the most simple form of the apparatus. In considering it, we will first suppose the battery to consist of five large Daniell's cells in series, so large that their resistance may be neglected. We will also suppose that the coil of wire on the revolving bar is made of a copper wire 389 ft. long, and $\frac{1}{16}$ of an inch diameter, or offering a resistance equal to one B A unit. Then, on connecting the terminals of this wire with the battery, and keeping the engine still, the current through the wire will be such as, with a horizontal force of earth's magnetism 3.678, would be able to deflect the small needle of a galvanometer furnished with a single circle of 1 ft. diameter, to the angle of 54° 23′. Also, this current going through the above wire for one hour will evolve heat that could raise 110.66 lbs. of water 1°, a quantity equal to 85,430 ft.-lbs. of work. In the mean time the zinc consumed in the battery will be 535.25 grains. Hence the work due to each grain of zinc is 1.596 ft.-lbs., and heat 0.20674 of a unit.

I. In the condition of the engine being kept still we have therefore, current being 1.396, as shown by a deflection of 54° 23′—

1. Heat evolved per hour by the wire, 110.66 units.

2. Consumption of zinc per hour, 535.25 grains.

3. Heat due to 535.25 grains, 110.66 units.

4. Therefore, the work per hour will be (110.66−110.66) 722=0.

5. And the work per grain of zinc will be $\frac{0}{535.25} = 0$.

II. If the engine be now started and kept by a proper load to a velocity which reduces the current to $\frac{2}{3}$, or 0.9307, indicated by deflection 42° 57′, we shall have—

1. Heat evolved per hour by the wire, $110.66 \times \{\frac{2}{3}\}^2 = 49.18$ units.

2. Consumption of zinc per hour, $535.25 \times \frac{2}{3} = 356.83$ grains.

3. Heat due to 356.83 grains, $110.66 \times \frac{2}{3} = 73.77$ units.

4. Therefore the work per hour will be $(73.77 - 49.18)\ 772 = 18983$ ft.-lbs.

5. And the work per grain of zinc will be $\frac{18983}{356.83} = 53.2$, or $\frac{1}{3}$ of the maximum.

III. If the load be lessened until the current is reduced to $\frac{1}{2}$ of the original amount, or to 0.698, we shall have —

1. Heat evolved per hour by the wire $110.66 \times (\frac{1}{2})^2 = 27.665$ units.

2. Consumption of zinc per hour, $535.25 \times \frac{1}{2} = 267.62$ grains.

3. Heat due to 267.62 grains, $110.66 \times \frac{1}{2} = 55.33$.

4. Therefore, the work per hour will be $(55.33 - 27.665)\ 772 = 21357$.

5. And the work per grain of zinc will be $\frac{21357}{267.62} = 79.8$, or $\frac{1}{2}$ of the maximum duty.

IV. If the load be still further reduced and velocity increased so as to bring down the current to $\frac{1}{3}$ of what it was when the engine was still, or to 0.4653, shown by a deflection of the galvanometer of 24° 57′, we shall have—

1. Heat evolved per hour by the wire $110.66 \times (\frac{1}{3})^2 = 12.294$ units.

2. Consumption of zinc per hour, $535.25 \times \frac{1}{3} = 178.42$ grains.

3. Heat due to 178.42 grains, $110.66 \times \frac{1}{3} = 36.89$ units.

4. Therefore, the work per hour will be $(36.89 - 12.294)\ 772 = 18988$ ft.-lbs.

5. And the work per grain of zinc will be $\frac{18988}{178.42} = 106.4$, or $\frac{2}{3}$ of the maximum duty.

V. Remove the load still further until the velocity increases so much that the current is brought down to $\frac{1}{100}$th of its quantity when the engine is still. Then we shall have—

1. Heat evolved per hour by the wire, $110.66 \times (\frac{1}{100})^2 = 0.011066$ of a unit.

2. Consumption of zinc per hour $535.25 \times \frac{1}{100} = 5.3525$ grains.

3. Heat due to 5.3525 grains of zinc, $110.66 \times \frac{1}{100} = 1.1066$ units.

4. Therefore the work per hour will be $(1.1066 - 0.011066)\ 772 = 845.73$ ft.-lbs.

5. And the work per grain of zinc will be $\frac{845.73}{5\ 352} = 158$, or $\frac{99}{100}$ of the maximum duty.

When the velocity increases so that the current vanishes the duty = 159.6.

I. Let us now improve the engine by giving it a coil of four times the conductivity, which will be done by using a copper wire 389 ft. long and $\frac{1}{8}$ of an inch diameter, the same battery being used as before. Then when the engine is kept still we shall have a current $1.396 \times 4 = 5.584$, shown by a deflection of 78° 51′. Then we shall have—

1. Heat evolved per hour by the wire, $110.66 \times (\frac{4}{2})^2 = 442.64$ units.

2. Consumption of zinc per hour $535.25 \times 4 = 2141$ grains.

3. Heat due to 2141 grains, 442.64 units.

4. Therefore, the work per hour will be $(442.64 - 442.64)\ 772 = 0$.

5. And the work per grain of zinc will be $\frac{0}{2141} = 0$.

II. Start the engine with such a load as shall reduce the current to $\frac{2}{3}$, or to 3.7227 (74° 58′), then we shall have—

1. Heat evolved per hour by the wire, $442.64 \times (\frac{2}{3})^2 = 196.73$ units.

1. Consumption of zinc per hour, $2141 \times \frac{2}{3} = 1427.3$ grains.

3. Heat due to 1427.3 grains $442.64 \times \frac{2}{3} = 295.08$ units.

4. Therefore, the work per hour will be $(295.09 - 196.71)\ 772 = 75934$.

5. And the work per grain of zinc will be $\frac{75934}{1427.3} = 53.2$, or $\frac{1}{3}$ of the maximum duty.

III. Lessen the load so that the velocity of the engine is increased until the current is reduced to one half its original amount, or 2792 shown on the galvanometer by a deflection of 70° 18′. Then we shall have—

1. Heat evolved per hour by the wire, $442.64 \times (\frac{1}{2})^2 = 110\ 66$ units.

2. Consumption of zinc per hour, $2141 \times \frac{1}{2} = 1070.5$ grains.

3. Heat due to 1070.5 grains, $442.64 \times \frac{1}{2} = 221.32$ units.

4. Therefore, the work per hour will be $(221.32 - 110.66)\ 772 = 85430$ ft.-lbs.

5. And the work per grain of zinc will be $\frac{85429}{1070.5} = 79.8$, or $\frac{1}{2}$ the maximum duty.

IV. Let the load be further reduced until the velocity reduces the current to $\frac{1}{3}$, or to 1.8613 shown by a deflection of 61° 45′. Then we shall have—

1. Heat evolved per hour by the wire, $442.64 \times (\frac{1}{3})^2 = 49.182$ units.

2. Consumption of zinc per hour, $2141 \times \frac{1}{3} = 713.66$ grains.

3. Heat due to 713.66 grains of zinc, $442.64 \times \frac{1}{3} = 147.55$ units.

4. Therefore, the work per hour will be $(147.55 - 49.182)\ 772 = 75940$ ft.-lbs.

5. And the work per grain of zinc will be $\frac{75940}{713.66} = 106.4$, or $\frac{2}{3}$ of the maximum.

V. Let the load be still further reduced until, with the increased velocity, the current becomes reduced to $\frac{1}{100}$, or to 0.05584, showing a deflection of 3° 12′. Then we shall have—

1. Heat evolved per hour by the wire, $442.64 \times (\frac{1}{100})^2 = 0.044264$ of a unit.
2. Consumption of zinc per hour, $2141 \times \frac{1}{100} = 21.41$ grains.
3. Heat due to 21.41 grains of zinc, $442.64 \times \frac{1}{100} = 4.4264$ units.
4. Therefore the work per hour will be $(4.4264-0.04426)\ 772 = 3383$ ft.-lbs.
5. And the work per grain of zinc will be $\frac{3383}{21.41} = 158$, or $\frac{99}{100}$ of the maximum duty.

Now, suppose that we still further improve our engine by making the stationary magnets twice as powerful. In this case all the figures will remain exactly the same as before, the only difference being that the engine will only require to go at half the velocity in order to reduce the current to the same fraction of its first quantity. The attraction will be doubled, but the velocity being halved no change will take place in the amount of work given out.

In all cases the maximum amount of work per hour is obtained when the engine is going at such a velocity as reduces the current to one half of its amount when the engine is held stationary, and in this duty per grain of zinc is one half of the theoretical maximum.

The same principles apply equally well when, instead of employing the machine as an engine evolving work, we do work on it by forcibly reversing the direction of its motion. Suppose, for instance, we urge it with this reverse velocity until the quantity of current is quadrupled or becomes 22.336 indicated by a deflection of 87° 26′. Then we shall have—

1. Heat evolved per hour by the wire, $442.64 \times 4^2 = 7082.2$ units.
2. Consumption of zinc per hour, $2141 \times 4 = 8564$ grains.
3. Heat due to 8564 grains of zinc, $442.64 \times 4 = 1770.56$ units.
4. Therefore, the work per hour will be $(1770.56-7082.2)\ 772 = -4100432$ ft.-lbs.
5. And the work per grain of zinc will be $\frac{-4100432}{8564} = -478.8$, or − three times the maximum working duty.

The principal reason why there has been greater scope for the improvement of the steam engine than for the electro-magnetic engine arises from the circumstance that in the formula $\frac{a-b}{a}$, applied to the steam engine by Thompson, in which a and b are the highest and lowest temperatures, these values are limited by practical difficulties. For a cannot be easily taken above $459° + 374° = 833°$ from absolute zero, since the temperature gives 12.425 atmospheres of pressure, nor can b be readily taken at less than the atmospheric temperature of $459° + 60° = 519°$. Also there is much difficulty in preventing the escape of heat; whereas the insulation of electricity presents no difficulty.

I had arrived at the theory of the electro-magnetic engine in 1840, in which year I published a paper in the fourth volume of "Sturgeon's Annals," demonstrating that there is "no variation in economy whatever the arrangement of the conducting metal, or whatever the size of the battery." The experiments of that paper indicate 36 ft.-lbs., as the maximum duty of a grain of zinc in a Wollaston battery. Multiplying this by 4 to bring it to the intensity of a Daniell's battery, we obtain 144 ft.-lbs. Here, as in the experiments in the paper on "Mechanical Powers of Electro-Magnetism, Steam, and Horses," the actual duty is less than the theoretic, which is owing partly to the pulsatory nature of the current, and partly also to induced currents giving out heat in the substance of the iron cores of the electro-magnets; although these last were obviated as far as possible by using annealed tubes with slits down their sides.

PROFESSOR E. B. ELLIOTT, of Washington, gives a life table of American sea-going sailing vessels, derived from the career of 26,737 vessels, of which 4,165 were known to be extant. The table shows that out of 1,000 vessels, 584.4 survive 10 years, 219.5 20 years, 57.2 30 years, 11.1 40 years, and none 50 years. The average duration of ships is 13.8 years; of those which have been built 10 years, 9.3 years longer; built 20 years, 7.2; 30 years, 6.2; 40 years, 2.7.

LONDON uses 8,000,000,000 cubic ft. of gas annually, costing \$8,000,000.

WET STEAM.*

By LEICESTER ALLEN, M. E.

The second annual report of the Inspector of Boilers of the city of Philadelphia states that, out of 56 men who presented themselves during the year 1870 for inspection and license as engineers and boiler-tenders, only 4 were considered first-class. Out of 39 who sought examination for a renewal of their licenses, only 9 were first-class. A large proportion were only third-class. I am not aware what the standard of classification adopted in Philadelphia is, but it is probably none too rigid. It is, probably, also fair to suppose that those who sought examination were better than the average of those employed to take charge of boilers ; since there is in that city no penalty imposed for the employment of unlicensed engineers or boiler-tenders. I deem it, therefore, extremely probable that the 4 receiving first-class certificates, out of the 56 examined, represent even a larger proportion of thoroughly qualified men than would be shown if a general system of examination and license were legally enforced.

In view of the general incompetence of those placed in charge of boilers not only in Philadelphia, but throughout the country, the use of boilers not only safe with good care and treatment, but safe even under neglect, has been gradually growing in favor, notwithstanding most of the boilers justly regarded as being incapable of exploding disastrously do not compete in point of economy with others which, unskilfully attended, are liable at any moment to explode with destructive violence.

The year 1870 has a most appalling record of death and destruction from boiler explosions, and it is time that the question of safety *versus* economy in the use of boilers should be definitively settled. The first step towards settling this question is the accurate determination of the real ratio of economy, in boilers admittedly safe under all circumstances, to those admittedly unsafe except when used with the best skill and fullest knowledge.

The safe boilers are those known as "sectional," in which very great strength in proportion to rupturing strain is attainable, and which—even if, under enormous pressure, they explode—cannot explode as a whole, but can only burst some minute portion of their structure. These boilers could, some of them, make a fair showing of evaporative power in proportion to consumption of fuel without forcing ; but in trials made to ascertain their steam-producing capacity, their exhibitors are apt to force them until they prime, and thus the amount of water passed through them becomes no index of their economical value as steam-generators. These boilers also present such an enormous heating surface in proportion to the water they carry, that in practical use they may be caused to prime by slight overfiring ; and with the ordinary care they get, it is little to be wondered at that it is an exception to find one of them delivering dry steam.

Any boiler has a limit of steam generation beyond which it cannot be pushed without priming ; and, on the other hand, any boiler has a limit of steam-producing capacity below which it will deliver perfectly dry steam. The amount of dry steam per pound of fuel actually burned that boilers will produce from water at 212 deg. Fahr. is the accepted standard of comparison as to their working economy. Experiments made by myself have, however, shown that, in very few cases where boilers are thus tested, absolutely dry steam is delivered ; the amount of water contained in the steam being in one case, which I now call to mind, certainly not less than 40 per cent. of the entire weight of mixed steam and water issuing from the boiler. This was, of course, an extreme case, in which the boiler was specially contrived, it would seem, to prime as much as possible. The evaporative power claimed for it by its sanguine inventor was 13 lbs. of water per lb. of coal consumed. All the way from this extreme up to absolutely dry steam, you may find boilers working if you will look for them. Boilers priming to the extent named, or even much less than that, are really unfit for service to supply engines with steam, and, I need

* Paper read before the New York Society of Practical Engineering, at the regular monthly meeting, April 26, 1871.

not say, are scarcely ever used for that purpose. But boilers often prime to a much greater extent than is suspected, in the absence of means to detect the exact amount of water mechanically carried over.

A common method of testing the quality of steam is to pass the hand through the jet of steam escaping—a method so rúde that it is really a disgrace to the science which has taught us that, with steam as a motor, everything may be reduced to mathematical certainty. I have known the estimate made by good judges to be 10 per cent. from the truth in making this test. The appearance and feeling of steam differ with the hygrometric condition of the atmosphere into which it rushes. On a clear, bright day, steam appears different from the same quality educted on a moist, foggy, and obscure day.

The method I have employed for testing the quality of steam, and the instrument devised for the purpose, is based upon the fact that steam at 212 deg. always contains 1,178 heat units per lb. and water at 212 deg., 212 units of heat per lb. It follows that, knowing the amount of heat issuing from a boiler in a lb. of mixed steam and water, the proportions of water and steam in the lb. can be easily determined. For, if x be used to represent the water in lbs., and y the steam in lbs., a the quantity of mixed water and steam educted in lbs., and b the total number of units of heat carried out in the mixed water and steam, we may form the equations

$$x + y = a$$
$$212\,x + 1178\,y = b.$$

from which we find the value of x to be $x = [1178a - b] \div 966$; or, to drop algebraic language, the amount of water contained in a given amount of mixed steam and water will be, in lbs., 1,178 times the weight of mixed steam and water, minus the number of units of heat it contains, divided by 966, the number of units of heat required to convert a lb. of water at 212 deg. Fahr. into steam at the same temperature.

To determine the amount of heat carried out by the mixed steam and water, I devised the following apparatus. A scale-beam with a platform, and a thickly felted water-chamber at one end, and a counterpoise at the other, has upon it a sliding weight, indicating lbs. and $\frac{1}{2}$ lbs. The walls of the water-chamber are made of thin tinned sheet-copper; there being 2 shells, between which felting, $1\frac{1}{2}$ in. thick, is placed. A felted cover is also provided, through which is inserted a standard thermometer, having a large bulb and easily read in 5ths of degs. A finely-perforated coiled copper pipe rests upon the inner floor, and passes out at the lower part of the side wall of the chamber. This is the steam-induction pipe. The bottom of the chamber is obtusely funnel-shaped; and from the lower part of the funnel is led out an escape-pipe. Both pipes are provided with cocks. A small funnel in the cover, also provided with a cock, completes the apparatus.

To use it, 5 lbs. of water are placed in the chamber through the funnel in the cover. The water is then raised to 80 deg. Fahr. by allowing a jet of steam—conveyed through a felted pipe—to enter through the coiled induction-pipe. The surplus water thus added is drawn on through the escape-pipe at the bottom of the chamber, leaving in the chamber 5 lbs. of water at 80 deg., containing 400 units of heat. The sliding weight is then set along into the $5\frac{1}{2}$ lb. notch, and the steam to be tested is then allowed to flow in till the scale-beam balances. Then the influx of steam is stopped, the thermometer is read, and the experiment is complete.

Suppose, now, the resulting thermometrical reading to be 180 deg. We then have 960 units of heat in the chamber, not counting in the amount absorbed by the thin copper lining—a very small amount indeed, and only noticeable theoretically; the general result is scarcely affected by its neglect. It follows that the amount of heat conveyed into the chamber in the lb. of mixed steam and water is 960—400 =560 heat units. Substituting this value for b in the above formula, we have (the value of a now being $\frac{1}{2}$) $[1178 - 560] \div [966 \times 2]$ which, reduced to hundreds, gives $31\frac{908}{1932}$ per cent. of water.

This instrument, for want of a better term, I have called the "steam hygrometer."

The standard quantity of water in the chamber, 5 lbs., the standard temperature, 80 deg., and the standard quantity of steam admitted in the experiment, $\frac{1}{2}$ lb.,

are chosen merely as matters of convenience. It is evident that, for any system of standards, the percentages for different resulting temperatures, between the minimum and maximum limits inclusive, may be computed and tabulated, so that, in testing boilers, no calculation need be made; the percentage for any resulting temperature being taken at once from the table.

HISTORICAL SKETCH OF THE CANALS OF CANADA.*

Of the great arteries of this Continent none surpasses the St. Lawrence in the length of its navigation, the volume of its waters, or the fertility of the vast area of country of which it forms the highway of communication with the Atlantic Ocean. Following it, not from its remote sources, but from Fond du Lac, at the head of Lake Superior, to the Straits of Belle Isle, the entire distance is 2,392 statute miles. In its course from Lake Superior to the sea, its volume is swelled by the waters of the Great Lakes, and smaller expansions, as well as by numerous tributaries of no insignificant size and importance. Between Lakes Superior and Huron, it is known as the Ste. Marie; between Huron and St. Clair, as the St. Clair ; between St. Clair and Erie as the Detroit ; between Erie and Ontario as the Niagara.

Below Quebec the breadth of this magnificent river increases until it is about 100 miles at its junction with the waters of the Gulf.

The importance of the St. Lawrence navigation has always been fully appreciated by the people of Canada, and large sums of public money have been wisely devoted towards the improvement of its facilities, not merely for internal and local, but for the ever increasing commerce of the basin of the Great Lakes. Not only has the channel of the river been deepened and otherwise improved, but an expensive system of canals constructed to overcome the natural obstructions, and connect the Lakes with tide water. Steamers, and ships of large tonnage, can now proceed directly from the ocean to Quebec and Montreal, a distance of 986 miles. From Montreal, however, to Lake Erie the capacity of the vessels is limited to the size of the canals, of which we propose now to give a brief historical and statistical sketch, before proceeding to state the conclusions at which we have arrived from the facts before us, and to show the immense interests connected with the important question which has been submitted to the consideration of the Commissioners.

The canals of Canada, now in operation, have been constructed for the purpose of improving the following routes of navigation :

First—The St. Lawrence navigation;

Second—The Montreal and Kingston, by way of the Ottawa and Rideau Canals;

Third—The Richelieu and Lake Champlain ;

Fourth—The Bras D'Or Lake (in Cape Breton) and the Ocean.

THE ST. LAWRENCE ROUTE.

First in importance is the St. Lawrence system of canals, which commences at Montreal, and ends at the foot of Lake Erie. On this route the works are known as the Lachine, the Beauharnois, the Cornwall, the Farren's Point, the Rapide Plat, the Galops, and the Welland, and have a total length of 71 miles, with a total lockage of 553 ft., through 54 locks.

Lachine Canal.—Above the city of Montreal, now the head of the ocean navigation of the St. Lawrence, are the rapids of St. Louis, perhaps better known as the Lachine Rapids ; and, in order to surmount this natural obstacle the present Lachine Canal was suggested soon after the conquest of Canada, and in fact its necessity was earnestly urged before the passage of the Constitutional Act in 1791. No practical steps, however, were taken toward the construction of the canal till the year 1815, when the Legislature passed a bill appropriating £25,000 in aid of its construction, at the recommendation of the then Governor General, Sir George Prevost. At that time its necessity in a military point of view was obvious to the military authorities ; and, no doubt, the work would have been immediately commenced after the passage of the Act had

* Abstract from the letter of the Canadian Canal Commissioners to the Secretary of State.

not peace ensued. Not until the year 1819 did the project again come before the public, and then the Act of 1815 was repealed and another passed for the incorporation of a Joint Stock Company, with a capital of $600,000, in $200 shares. This scheme also proved abortive, for on the 26th of May, 1821, a bill was passed through the House repealing the Act of Incorporation, and authorizing the Government to construct the Montreal and Lachine Canal as a Government work. Commissioners were immediately appointed to superintend and carry out the project, and on the 17th July of the same year ground was broken at Lachine.

The British Government contributed £10,000 sterling, or $50,000, towards the accomplishment of the work, on the condition that all military stores should pass free, and the Province paid the remaining expenditure on the canal, the whole cost of which, to the end of 1826, amounted to $438,404.15.

The canal was opened for the passage of vessels in 1825. It was 28 ft. at the bottom, 48 ft. at the water-line, with $4\frac{1}{2}$ ft. depth of water ; with seven locks 100×20 ft. built substantially of stone.

The canal, as first constructed, was very soon found to be inadequate to the requirements of commerce, especially of Upper Canada. When the project of uniting the Canadas became the great question of ths day, Lt.-Colonel Phillpotts, acting under the instructions of the Earl of Durham, reported in favor of an improved canal navigation, with locks throughout of the same dimensions as had been adopted for the Cornwall Canal, viz.: 200 ft. in length by 55 in breadth, and 9 ft. of water on the sills. Col. Phillpotts also proposed a new line for the Lachine Canal, and estimated the total cost of the suggested improvements at $1,579,720. After mature deliberation, however, as to the exigencies of the Lake trade, then in its infancy, it was decided to retain the old location of the canal, and to enlarge it to 200 ft. by 45 ft. for the locks, with 9 ft. of water on the sills ; a width of canal 80 ft. at bottom, and 120 ft. at water surface, the length remaining as before, $8\frac{1}{2}$ miles. During the alteration navigation was not discontinued, for the new locks were constructed by the side of the old ones.

In 1844, in the course of the progress of the improvements, it was decided, at the earnest solicitation of the mercantile community of Montreal, to deepen locks 1 and 2 to 16 ft. of water on the sills, so as to admit the largest sea-going vessels then trading to Montreal, into the first basin of the canal. In the spring of 1848, the works were sufficiently enlarged to admit the passage of craft. It was not, however, till the month of May, 1862, that the canal was excavated to its full width, a very expensive undertaking, as the cutting is through the silurian limestone for some distance inland.

The present canal is of the following dimensions :

Length	$8\frac{1}{2}$ miles.
No. of Locks	5
Dimensions of Locks	200×45 ft.
Total rise of Lockage	$44\frac{3}{4}$ "
Depth of Water on Sills	
At 2 Locks	16 "
At 3 "	9 "
Breadth of Canal at bottom	80 "
" " Water surface	120 "

Beauharnois Canal.—The Beauharnois Canal was the inevitable sequence of the Lachine, and the improvement of inland navigation, and was built to overcome the rapids called the "Cascades," "Cedar," and "Coteau," occupying altogether a distance of 7 miles, and to afford safe navigation between Lakes St. Louis and St. Francis.

In the earlier period of Canadian trade, the most sanguine commercial minds hardly appreciated the progress it would make before half a century had passed away. Four short canals gave facilities to boats carrying 30 barrels of flour for passing from Lake St. Francis into Lake St. Louis. Several minor improvements were made in this part of the St. Lawrence navigation, according as the exigencies of business demanded, but by the year 1833, the question became of such pressing importance that the Government of Lower Canada appointed commissioners to consider all matters relating to the navigation of the St. Lawrence, between Lachine and Cornwall. Mr. Mills, the Engineer of the Commissioners, submitted several plans based on the dimensions adopted for the Cornwall Canal, and his report was referred to a special committee of the House, who approved of it, and recommended a grant of $960,000 towards carrying out its recommendations, which proposed, as the best plan, short canals at the three

rapids, and using the river between them.

This report, however, fell still-born, and was followed by others, from Mr. A. Stevenson in 1834, and Messrs. Stevenson & Baird, in 1835, to equally little purpose. In 1834, Col. Phillpotts, before referred to, recommended a canal on the north side of the river, for military reasons, though he acknowledged at the same time that it was probable one on the south side would cost less.

It was not until the summer of 1842, that the contracts were entered into for construction nearly on the route proposed by Mr. Stevenson in 1834.

By the close of navigation in 1845, the canal was opened, but it was then found that its upper entrance was imperfect, its channel crooked, and not sufficiently deep in dry weather, and impeded by cross currents; other difficulties also presented themselves, and in the course of years, up to a very recent date, dams, regulating weirs and dykes have been erected at large expense to the country, in order to give the requisite facilities to the trade passing through the canal. Much difference of opinion existed at the time of the inception of the work, and has continued down to the present day with respect to the best route of the canal—many persons contending that for military reasons it should have been located on the north side—others arguing that its natural position is where it is now situated; but the Commissioners have no intention of going into this question.

The following are the dimensions of this work at the present time:

Length	$11\frac{1}{4}$ miles.
No. of Locks	9
Dimensions of Locks	200 feet×45
Total rise of Lockage	$82\frac{1}{2}$ "
Eepth of Water on Sills	9 "
Breadth of Canal at bottom	80 "
" " water surface.	120 "

Cornwall Canal.—The next canal which comes in natural order is that which extends from the town of Cornwall to the village of Dickinson's Landing, on the north shore of the river, to overcome the obstructions known as the Long Sault Rapids. From the sketches already given of the other canals, it will be seen that this work was actually the first in the series constructed on the present scale, and that its dimensions was the standard for the others. As far back as the year 1817, the Governor of Upper Canada, in his speech at the opening of the Legislature, called the serious attention of Parliament to the important question of the navigation below Prescott. In 1818, a joint commission was appointed by the Government of Lower and Upper Canada, and reported in favor of improvement between Montreal and Lachine, between the head of Lake St. Louis and Lake St. Francis, and also at the rapids above Lake St. Francis. They recommended the construction of canals of a limited capacity—not more than four feet deep; but no definite legislative action took place on the subject until December, 1826, when a Report was laid before Parliament by the Governor, showing the length of the proposed canals between Lakes Ontario and St. Francis, and their probable cost. The question, however, remained in abeyance until 1832, when the House of Assembly of Upper Canada passed measures appropriating the sum of $280,000 for the improvement of the navigation of the St. Lawrence, so as to admit vessels drawing 9 ft. of water, and recommending the immediate commencement of such improvement between Cornwall and the head of the Long Sault Rapids. One of the stipulations of the Act was the completion of the Cornwall Canal before any of the other proposed works, leading to Lake Ontario, should be undertaken. In 1833, a commission was appointed for the purpose of carrying out the provisions of the Act, and Mr. Benjamin Wright was employed as engineer with authority from the Government of Lower Canada to make the survey of the lower canals, on a scale commensurate in all respects with those of the Upper Province.

Without going into unnecessary details, it will be sufficient to mention that the engineers determined on locks 55 ft. wide, 200 ft. long between the gates, with 9 ft. depth of water on the mitre sill; canal 100 ft. wide at bottom, to admit the passage of steamboats; these would allow the passage of vessels 175 to 180 ft. long. That, for the improvements proposed at the four several places above the Long Sault, where vessels would only use the canals when going up, and run the rapids when going down, the breadth of the canals should be only 50 ft. at bottom.

The suggestions of the engineers were

adopted by the Legislature, and commissioners were subsequently appointed to superintend the works. The services of Messrs. Wright and Mills were engaged as engineers, as well as those of Captain Cole, R. E., and Messrs. Geddes and Fleming. In 1834 the work was put under contract, and the first sod cut with considerable ceremony by the late Sir John Beverly Robinson.

The rebellion, as well as financial causes, retarded the completion of the work for some years. The passage of the first steamer, in December, 1842, through the locks, was the occasion of some ceremony, but it it was not until the month of June, 1843, that the work was formally opened.

Since the completion of the works, several improvements have been authorized for the purpose of increasing the depth of water, and giving other facilities to vessels passing through the canal. At the present time the canal is of the following dimensions ;

Length.................	$11\frac{1}{2}$ Statute miles.
No. of Locks...........	7
Dimensions............	200 ft. × 55ft.
Total rise of Lockage....	48 "
Depth of Water on Sills,	9 "
Breadth of Canal at Bottom..................	100 "
Breadth of Canal at water-surface..............	150 "

The Williamsburg Canals.—We have now come to that series of canals known as the Williamsburg, viz: The Farran's Point, Rapide Plat, and Galops Canals.

The Farran's Point Canal extends from the foot to the head of the rapids in that locality, on the north side of the river, and is only used, as a rule, by vessels coming up the river.

Before the question of the Cornwall Canal was mooted, the construction of the work had been discussed, and some surveys made of the place ; but it was not until four years after the Union between Upper and Lower Canada, that the work was actually commenced. The canal was completed for traffic by October, 1847.

The Rapide Plat Canal, the second of the series, extends on the north shore from Morrisburg to the head of the swift current, and has been rendered necessary by the rapids from which it takes its name. Several reports were made respecting this work previous to the Union, but it was not until 1843 that the necessary surveys were made.

The works were commenced in the spring of the ensuing year.

The Galops Canal was constructed to avoid the rapids at Point aux Iroquois, Point Cardinal, and the Galops, and is also on the north side of the St. Lawrence. Mr. Benjamin Wright, as early as 1833, recommended the construction of canals to avoid these obstructions, and Colonel Phillpotts subsequently approved of his plan, which was not, however, carried out. In 1843, the Board of Works of the United Provinces prepared a design which was adopted and carried immediately into effect. This design was the construction of a canal 3 miles long to avoid the Iroquois Rapids, the use of the waters of the St. Lawrence for a distance of $2\frac{5}{8}$ miles, and then the construction of another canal from the foot of the Galops Canal Rapids, $2\frac{1}{4}$ miles long. Both these canals were opened to the public in September of 1847 ; but it was soon seen that the Iroquois Canal had not a sufficient depth of water for vessels ascending, and it was therefore found necessary to connect that work with the Galops.

The Junction Canal, the name of the central section for a time, was finally completed in 1856, and the three works are now known under the one designation of the Galops Canal.

The Welland Canal.—After leaving the "Galops" we have to travel a distance of 226 miles, partly by the river, but chiefly by Lake Ontario, and then we come to, perhaps, the most important part of our canal system—the Welland Canal, which connects Lake Ontario with Lake Erie, by carrying the navigation around the famous rapids and falls of the Niagara River The early history of this work shows what difficulties attended its commencement, and it is obvious that had not the public men of Canada become in time fully alive to the importance of the interests involved in its construction, the Welland would not have been built as soon as it was. It would be impossible within the limits proposed for this sketch to give anything like a full history of the obstacles that impeded for years the successful accomplishment of this all-important outlet for the trade of the western country.

As early as the month of February, 1816, a joint Committee of both Houses of the Parliament of Upper Canada reported on this and other works connected

with inland navigation, and Colonel Nichol subsequently introduced a bill to appropriate money for a complete survey of the best route of water communication between Lakes Erie and Ontario, as well as between Lake Ontario and Montreal. No decisive action, however, resulted from this step, and we do not again hear of the project until two years later, when a Committee of the House reported favorably on a petition from the people of Niagara (old Newark), and suggested the formation of a Committee to carry out the work. In 1821 a Commission was appointed to consider the subject of Inland Navigation, and it reported in 1823 in favor of constructing the Welland of such dimensions as would accommodate the class of vessels then navigating the lakes. The result of this report was the incorporation of a private company, on the petition of W. H. Merritt and others, in 1824, under the title of the Welland Canal Company, who proposed to establish the necessary communication by means of a canal and railway. They intended running up the natural waters of the Welland River, and to pass across the township of Thorold, tunnelling through the high ridge of land about a mile and a half, and then proceeding directly by a canal to the brow of the high land ; then a railway was to descend the high land, and connect by means of another canal with the navigable waters of Twelve Mile Creek, so as to afford the required egress to Lake Ontario. The canal portion was to be of capacity sufficient to accommodate boats of not less than 40 tons burden.

Public meetings were called, surveys made, and other steps taken to excite public opinion in favor of the undertaking; but it will show how little interest was taken, when we mention the fact stated in an official document, that at the ceremony of breaking the ground, on the 30th November, 1824, not half a dozen gentlemen of capital or influence in the district attended. By 1825, the former scheme was considered objectionable, and a new one adopted for the admission of schooners and sloops. It was determined to have the entrance at the mouth of the Creek or Port Dalhousie, and the upper terminus at the Welland River, from whence the supply of water for the canal was to be drawn. It was also contemplated, at an early day, to establish a communication between the Welland River and Lake Erie, so as to avoid the impediments to navigation below Fort Erie. It was proposed to have wooden locks 110 ft. in length by 22 ft. in breadth, the cross section with 26 ft. at bottom and 58 ft. at the surface of the water, except through the deep cut, which was to be only 15 ft. wide at bottom; for two miles the depth of water was to be 8 ft.

In the summer of 1825, the Company set to work to carry out their project with an ostensible capital of $800,000, and their history thenceforth was one of financial embarrassment.

In 1826 they obtained a loan of $100,000 for three years from the Upper Canadian Government, and a promise of a contribution of one-ninth of the estimated cost from the Imperial Government on certain conditions—the locks to be 22 ft. wide and all property of that Government to pass free. In 1827, the Government of Upper Canada took stock in the undertaking to the amount of $200,000, and the Government of Lower Canada to the extent of $100,000. The Imperial authorities gave a grant of 13,000 acres of land in the vicinity of the canal, and subsequently gave a loan of $200,000 for ten years at 4 per cent. interest. In 1828, a slide of earth occurred in the excavation of the Deep Cut and added greatly to the embarrassments of the Company, for it obliged them to abandon the Welland River as a feeder. The Company finally adopted the Grand River as a new feeder, and carried on the works with considerable energy, for water was let into the canal in the fall of 1829, and in the month of November, exactly five years after the time the works had been commenced, two schooners, one of 85 tons burthen, the other of smaller size, ascended the canal from Lake Ontario to the Welland River. Then the Company, having accomplished so much, thought it an opportune time to seek further aid from the Government, for the purpose of carrying out the work to completion. They prayed the Legislature to grant $100,000 and to allow them to increase the Capital Stock to $1,200,000; and after considerable discussion, the vote in favor of the project was carried by very narrow majorities. Subsequently the Company proposed to extend the main line of canal over the Welland river to Port Colborne (Gravelly Bay) by

enlarging about 5 miles of the feeder and excavating a new canal for the remaining distance to the Bay.

In 1831, the Government approved of this project and granted a loan of $200,000 for the completion of the work, which was immediately commenced, and completed in 1833. At this time, the canal occupied nearly the same site as the present one, but the locks were of small dimensions and exclusively of wood.

No works of importance were constructed on this canal until after the union of the two Provinces. In 1837, the Government took the step of converting all its loans up to that time into stock, and was authorized to subscribe $980,000 new stock. The capital stock of the Company was declared to be $1,195,200, and the Directors were limited to an expenditure of $400,000 during the year. In 1839, an Act was passed in Parliament by a vote of 26 against 9 to authorize the Government to purchase all the private stock, so that the work should become public property; but no steps were taken, in consequence of financial difficulties, to carry out that design, until 1841, when the works were placed under the control of the Board of Works. The total expenditure by the Government on the canal, amounted at that time to $1,851,427.77; but as the work was inadequate to the requirements of the trade, it was decided to enlarge the canal, but not to the full extent proposed by Col. Phillpotts in 1839, viz: Locks 200 ft. long by 55 broad. It was, however determined to rebuild all the locks with stone, 120×24 ft., with 8½ ft. of water on the sills; that the aqueduct should also be rebuilt with stone; that the feeder should be converted into a navigable canal; that the harbors of Port Dalhousie and Port Colborne should be improved; that the two first locks at Port Dalhousie, and the one at Port Colborne, should be 280×45 ft. with 9 ft. of water on the sills; and finally that the Port Maitland branch should be undertaken and completed with an entrance lock from Lake Erie 200×45 ft., with 9 ft. depth. Henceforth the progress in the improvement of the works was systematically and successfully conducted, until the canal reached its present condition, of which the following statistics afford an idea:

	Main Line from Lake Ontario to Lake Erie.	Welland River Branches.	Grand River Feeder.	Port Maitland Branch.
Length of canal	27 miles and 1.099 feet	Port Robinson Cut to Welland R., 2,622 feet Welland Canal to Welland River—no lock at Aqueduct, 300 feet Chippewa Cut to Niagara R., 1,020 feet.	21 miles	1¾ miles.
Pairs of guard gates	3			
Number of locks	27 lift locks	1 at Aqueduct and 1 at Port Robinson, 2.	2	1
Dimensions of locks	2 of 200 × 45 feet.. 24 of 150 × 26½ feet 1 of 230 × 45 feet..	150 × 26¼ feet....	1 of 150 × 26½ ft. 1 of 200 × 45 feet..	185 × 45 ft.
Total rise of lockage	330 feet 2 × 8 = 16 Grand R level.	....	7 to 8 feet	8½ feet.
Total lockage	346			
Depth of water on sills	10¼	From Welland Canal down to Welland River, 17 feet.		
Total cost to 1st July, 1867	$7,638,239 83	9 feet 10 in.	10¼ feet	11 feet.

Burlington Bay Canal.—Another work which may be considered to form a part of the St. Lawrence navigation, is the Burlington Bay Canal, which enables vessels to reach the city of Hamilton from the Lake. It is simply an open cut across a sand bar at the entrance of Burlington Bay; it is half a mile long, with an average breadth of 138 ft. between piers, and is navigable for vessels drawing 12 ft. of water. On the 19th of March, 1823, a bill was passed in the Legislature of Upper Canada authorizing the construction of this work, which was completed by 1832.

The Canadian system of canals connect-

ing the Lakes with the St. Lawrence, ends with the Welland. At Sault Ste. Marie, however, the Americans have constructed a canal $1\frac{1}{17}$ mile in length, with locks capable of allowing the passage of vessels of 2,000 tons. In this way the trade of Lake Superior finds its outlet to Buffalo and other ports on Lake Erie. The Americans have also improved the navigation through Lake George and over the St. Clair Flats.

THE OTTAWA AND RIDEAU ROUTE.

We shall next refer to the second part of the canal system of Canada, viz., the works between Ottawa and Montreal, and between Ottawa and Kingston, which may now be considered as feeders to the trade of the St. Lawrence.

In the Annual Reports of the Department of Public Works the line of navigation which these canals facilitate is given as the "Montreal and Kingston *via* Ottawa and Rideau Canals." These canals are called the "Ste. Anne," or rather the "Ste. Anne Lock," the "Carillon," the "Chûte à Blondeau," the "Grenville," and the "Rideau," and have a united length of $142\frac{7}{8}$ miles, inclusive of the Lachine.

The Ste. Anne Lock was constructed for the purpose of enabling vessels to pass the rapids of the same name, situated at the junction of the Ottawa with the St. Lawrence. The work was recommended by the Legislature of Lower Canada, as far back as 1831, and reported upon by Col. Duvernet, R. E.; but various causes contributed to prevent the commencement of the work until the 18th May, 1840, by the Board of Works. By the end of June, 1843, boats were able to pass through the canal, and the work was completed finally in the autumn of the same year. Since that year, various improvements have been made in the work.

Next in order come the Ordnance or Military Canals, known as the Carillon, the Chûte à Blondeau, the Grenville, and the Rideau. The Carillon is distant 27 miles from Ste. Anne, and was constructed on the north side of the Ottawa River, to avoid the "Carillon" Rapids. It was projected in 1819, and subsequently completed under the direction of the "Royal Staff Corps," and at the expense of the British Government.

The Chûte à Blondeau lies on the north side of the river, 4 miles above Carillon, and is constructed through solid rock to avoid the rapids from which it takes its name. It was also designed at the same time as the Carilion, by the Royal Staff Corps.

The Grenville follows the Chûte à Blondeau, $1\frac{5}{8}$ miles further up, and lies also on the north side of the river, with the object of surmounting the rapids known as the Long Sault. Its history is that of the two previously mentioned works. So far as the records go to show the Grenville was the last work completed; but the first passage through all of them was not made until the latter part of April, 1834, when the steamer St. Andrew's passed through them.

The Rideau Canal extends from Ottawa City to Kingston, and makes the Rideau and Cataraqui navigation available for craft of a certain depth of water, for a distance of $126\frac{1}{4}$ miles.

The necessity for the construction of such works was seen during the war of 1812, and in the year 1815, Capt. Jebb, of the Royal Engineers, was sent by the military authorities to examine into the practicability of finding a satisfactory route. This gentleman reported favorably on the project, but no decisive action was then taken in reference to it by the Imperial Government. In 1824, they offered a loan of $340,666.67 towards the construction of the canal, and Mr. Clowes was thereupon instructed by the Upper Canadian Commissioners appointed previously on the question of Inland Navigation, to make a survey of the proposed work.

He submitted 3 plans, and in 1825, the committee to whom his report was submitted, recommended the adoption of the one with 5 ft. of water. The Government of Upper Canada, however, on full consideration, declined to construct the work, as they believed the improvement of the St. Lawrence navigation was best calculated to promote the commercial interests of the country, and that the accomplishment of the work should devolve on the Imperial Government, if it was necessary chiefly for military reasons.

Accordingly the Imperial Government sent out a Commission of Royal Engineers to report on the work, and subsequently determined to construct it. In the autumn of 1826 Col. By, R. E., arrived from England, and immediately commenced the

construction of the works, Sir John Franklin laying the foundation stone. The works were completed in the spring of 1832, and the steamer Pumper passed through from Bytown to Kingston.

Length of canal	126¼ miles.
Number of locks	47
Total lockage	446¼ ft.

RICHELIEU CANALS.

The third series in the canal system of Canada is that which has been constructed to connect the St. Lawrence with the Hudson *via* the Richelieu and Lake Champlain. The Richelieu river is situated 46 miles below Montreal, and 114 miles above Quebec. The obstructions to its navigation are removed by a canal at St. Ours, 14 miles from its mouth, and by another, 32 miles further up, known as the Chambly Canal. The route is thence free from difficulties for the remainder of the river Richelieu and Lake Champlain, at the head of which the Americans have a canal properly called the Whitehall Canal; by means of this and a small portion of the Erie Canal, boats are enabled to reach the Hudson at Albany, 311 miles from Montreal.

The Chambly Canal was suggested, like most of the Canadian canals, after the experiences of the American war of 1812.

The Chambly Canal lies on the west side of the Richelieu, extending from Chambly basin up to St. John, 12 miles. On the appointment of the Commissioners in 1829, they ordered the necessary surveys to be made, and 2 years later the work was regularly placed under contract for the gross sum of $184,872, but the contractors were obliged to suspend on account of having taken the work at too low a rate. Considerable progress, however, had been made in the construction of the canal, and when the state of affairs had been reported to the Legislature, a bill was passed through the Houses, in 1835–36, granting the requisite funds, but it also failed to receive the royal assent. During the ensuing year the want of funds continued to be the difficulty, and it was not until 1841 that the work was taken energetically in hand by the Board of Works.

The canal was opened two years later, but the work was found to be in a very unsatisfactory condition, and at last, in 1858, it had to be renewed to a large extent.

The Saint Ours lock and dam was commenced in 1844 under the Board of Works, and was completed in 1849.

ST. PETER'S CANAL.

The only canal in actual operation in the Maritime Provinces is that which connects the Bras D'Or lake of Cape Breton with the ocean. The width of the isthmus separating the sea from the lake, which is a noble sheet of water, abounding in fish, and surrounded by a country rich in mineral and agricultural resources, is only ½ a mile. The project of canalling it was mooted at an early date by the representatives of Cape Breton in the Legislature of Nova Scotia. In 1821, a survey was made by Mr. Francis Hall, and other surveys by Mr. C. W. Fairbanks, and Captain Barry in subsequent years. The design of the latter, for a canal 22 ft. wide at bottom, and 13 ft. deep, was adopted, and the work commenced on September 7th, 1854, and continued until 1858, when Mr. Laurie, then Chief Engineer of the Province, made an unfavorable report as to the probable remunerative results of the work, and suggested a marine railway as the best means of accommodating the trade of the locality. The works were then suspended for some time, but the Cape Breton representatives continued urging the necessity of the undertaking, and the construction of the canal was resumed in 1864. The St. Peter's Canal was among the public works handed over to the Dominion in 1867, since when the work has been completed; and is now 2,400 ft. long; with a breadth of 26 ft. at bottom; with one tidal lock, 26 by 122 ft., and 4 pairs of gates. The depth of water in sills, at lowest water, is 13 ft.; the extreme rise and fall of tide in St. Peter's bay, being about 9 ft.

Projected Canals.—Besides canals in operation, several others have been projected of recent years, with the avowed object of affording greater facilities for the trade of Canada.

Prominent among these schemes is what is generally known as the Toronto and Georgian Bay Canal. The distance between its Southern terminus, in Humber bay, of Lake Ontario, and its Northern terminus, in Georgian bay, of Lake Hu-

ron, is 100 miles, of which 24 are deep water navigation, through Lake Simcoe, which is to be the summit level and feeder. Nearly 20 years ago Mr. Kivas Tully made the first exploration of the line of the proposed canal, and of late years the project has been energetically advocated by gentlemen in Toronto and elsewhere, incorporated as the "Huron and Ontario Ship Canal Company."

Another scheme is that for the construction of a branch canal from the town of Niagara to connect with the Welland at Thorold. Mr. Walter Shanly reported favorably on the project in 1854, and during the last Session of the Legislature, a bill was passed for the incorporation of the Ontario and Erie Ship Canal Company, from the waters of Niagara river, at or near Fort George, in Niagara, thence to Thorold, and thence to the waters of Lake Erie, at or near Port Colborne, or the Niagara, at or near Chippewa ; locks to be the size of the Cornwall Canal. The capital, $8,000,000, in shares of $100, with power to borrow to the extent of unpaid capital. The work to be commenced within 2 years, and finished within 5.

The Murray Canal was advocated as far back as 1797, when a resolution was formally adopted by the Lt.-Governor in Council for the reservation of 3,000 acres of land in favor of the construction of the work. The necessity of the work has, since then, been frequently brought before the Legislature, and surveys of the route were made. As late as July, 1866, a committee of the House of Assembly of Canada authorized another survey, which was made.

The Caughnawaga Canal is another scheme which has been earnestly advocated for some time past. It was first prominently brought before the public by Messrs. John Young, L. H. Holton, and other merchants of Montreal in 1847, and in answer to their petition the then Governor-General, Lord Elgin, instructed Mr. J. B. Mills, C. E., to make a survey. In 1848, this gentleman reported in favor of a canal having the upper terminus at St. John, and the St. Lawrence terminus, near the village of Caughnawaga, immediately opposite Lachine, about 8 miles above Montreal. In 1852, the Commissioner of Public Works strongly urged the construction of this canal, and subsequently other surveys were made and reported upon, but no Government action was ever taken on the subject. Other gentlemen, especially the Hon. John Young, however, kept the scheme prominently before the public, and in the last Session of Parliament a bill was passed incorporating a number of gentlemen into a company to build the Caughnawaga Ship Canal, from Lake St. Louis in the St. Lawrence to Lake Champlain, on the Richelieu, with power to use and enlarge the Chambly Canal, with consent of the Government, who may, however, at any time assume the whole work—the locks not to be of less size than those on the Beauharnois Canal. The capital stock $3,000,000, with power to increase to $4,000,000, in shares of $100. The canal to be completed within 5 years, or charter forfeited.

One of the most important schemes which have been brought before the public of late years is undoubtedly the Ottawa Canal, to connect Montreal with Lake Huron, *via* the Ottawa river, Lake Nipissing, and French river. The route was examined by two engineers, first in 1857, and afterwards in 1859, and their reports are found in full in the reports of the Department of Public Works. The subject has been frequently before Parliament, but no definite steps ever taken to carry out the project.

Another canal which has come prominently before the public of late years, is what is generally called the Bay Verte Canal, to connect the waters of the Gulf of St. Lawrence, at Bay Verte, with those of the Bay of Fundy, at Cumberland basin, by cutting across the Isthmus of Chignecto, uniting Nova Scotia with New Brunswick. In 1825 a survey of the route was made by Mr. F. Hall at the instance of the Lieutenant-Governor of New Brunswick. At a later date, Mr. Thomas Telford, C. E., revised the report of Mr. Hall, and suggested a canal with a depth of 14 ft., with a view of accommodating the large trade that must accrue especially with Quebec, Montreal and the Upper Lakes. In 1843, Captain Crawley made another survey—Canada paying a portion of the expense. A survey of the line is now in progress at the instance of the Dominion Government.

TEXAS is better timbered than any other State.

THE PLACE VENDOME COLUMN.

From "The Engineer."

On the 18th February, 1805, Mr. Pitt demanded of the House of Commons five millions—"required for continental purposes"—and in July a still larger sum was voted him, the object being the establishment of a coalition of the German and Russian powers against Napoleon, who, practically master already of the Continent, was watching his chances of invading our own island. The news that the coalition was formed, reached the great leader the same month, and, with the unerring insight and electric rapidity of decision that formed such great elements in his mighty successes, he instantly broke up his camps, turned his back to our shores, and, by the 9th of September, had invaded Bavaria. On the 25th of the same month six marshals of France, with as many army corps, crossed the Rhine, and rapidly penetrated Central and Southern Germany, gradually concentrating towards Napoleon. Within thirty-six days from setting out from Boulogne, he had struck the first effective blow at Donauwerth on the Danube. On the 20th October Mack capitulated at Ulm, and about 40,000 Austrians and Germans were made prisoners, leaving the way to the heart of Austria almost open. At 3 o'clock in the early afternoon of a clear and sunlit winter's day, the 2d of December, 1805, the Battle of Austerlitz had been fought and won, 40,000 Austrians and Russians were *hors de combat*, and 266 guns remained in the hands of the victorious Emperor. The coalition for which Pitt had labored was broken up; the subsidies, then viewed by Englishmen, and justly, in proportion to the then existing national wealth and burdens, as a vast sum—though such as maladministration now wastes in a few months—had been lavished in vain, and the heart of the great patriot and statesman, Pitt—the pilot whose policy in the end, however, did really enable us to weather the storm—was broken.

Prussia had never heartily and honestly joined the coalition, and reaped the fruits of her double dealing before long; her king, who had so far played "cat in pan," at once hastened to offer his felicitations. "*Voila un compliment*," said Napoleon, "*dont la fortune a change l'addresse;*" contempt was enough for the present, vengeance was to come, and the victor marched to complete his marvellous campaign of only ten weeks at Schönbrunn. Austria was humbled and crushed, Russia checkmated, and Prussia in crouching dread of what should follow. Early in 1806 the Emperor was back at Paris, and decreed that 1,200 bronze guns captured, should be devoted to the erection of a bronze-covered column, after the style of that of Trajan, at Rome—erected there by his architect, Apollodorus, to mark the site of the hill of equal altitude, 110 ft., which had been removed to make way for Trajan's Forum—which should stand as a perpetual memorial of those great deeds of France, and of its army and imperial leader. And this is the monument that France and her marshals and army, the Government for the time, and the citizens of Paris, have proved powerless to prevent being destroyed by the very dregs of the capital—still by Frenchmen's hands—and whilst the conquering German still treads their soil. The grand column is no more now than a dusty and ragged stump of a few feet in height above its plinth, and its spiral rings of recorded triumphs, and the statue they bore of the genius that compassed them, lie shattered upon the ground to which they were dragged down, after some rings of the bronze spirals had been removed, and the stone core sawn through to facilitate the fall. It is not our part to moralize or descant upon the events that produced, or those that have permitted, this senseless destruction of the column; but while the event is still fresh our readers will, no doubt, like to have some particulars as to the circumstances of its construction and erection. The chief portion of what we are about to state is scarcely known to the British public, and even in France is known to but few, and these of a generation fast passing away. We have been fortunate enough to obtain drawings of the original foundry and apparatus employed in casting the bronzes.

The execution of the decree for the erection of the column nominally devolved on the Minister of Public Works. A commission, of which the celebrated Dénon

was the head, became the actual authorities, MM. Gondouin and Lepere being the professional members of it, the first as architect, the second as sculptor. M. Jacques Gondouin died at Paris in 1818, at the age of 81. He had been a pupil of Blondel, and was, prior to the great Revolution, an eminent architect of the grand but heavy style of Louis XIV., and with vast practice. But the Revolution fell heavily upon the favorite architect of the *noblesse*, and it was only under the Empire that he began to recover his lost position, when already a very old man. He had been the architect, amongst other large works, of the *Ecole de Medicine* in the *Quartier Latin*, the great theatre of which, holding 1,200 pupils, is a model of what such a room should be.

Dénon was known as an archæologist and man of letters and taste, and actual editor of the great national work on Egypt, having been one of the *savants* who had accompanied General Bonaparte in his expedition there. Lepere had acquired a considerable professional reputation. None of the commission seem, however, to have been good men of business; and adopting the same procedure which had a few years before been so disastrously employed with respect to the monument to Dessaix, got into very much the same sort of difficulties. The modelling of that monument having been finished, the casting of it was set up to public competition, and a small bell founder got the contract; and in the end—for we cannot pause to recount details—in place of casting it all in one piece, he cast it in pieces which ill fitted to each other. The production of the bronzes for the column was in the same way set up to competition, and an iron-founder, named Launay or DeLaunay—he so signs himself—got the contract. He undertook to mould and cast all the pieces at the absurdly low price of one franc per kilogramme, or at about 5d. per pound, which included the dressing of the bronze castings, the chiselling or chasing of the cast surfaces wherever necessary, and the fixing them in place. The other chief conditions were, that the founder was to have at his disposal the foundry constructed by the Municipality of Paris for the production of the grand equestrian statue of Louis XIV., a certain sum for supplying it with additional plant, that the necessary quantity of bronze guns, with an allowance of 10 per cent. for waste in casting, were to be delivered to him, and also the models in plaster for the castings, which were to be in duplicate where he should so require. De Launay was an iron founder far from wanting in ability. It was he who made the castings and iron work of the bridge of Austerlitz, and of the Pont des Arts at Paris, and he had produced the design and model for the then very large iron dome roof of the Halle au Blé, to replace that of timber which had been burnt, and which, with slight alteration, was carried out by the great architect, Rondelet. It is also upon official record that it was he who devised the method of melting silver in cast-iron in place of clay crucibles, long employed in the French mint and until very recently in our own. He was, at a subsequent period, also author of a small work on founding in various metals—of little merit, however. He had had no experience whatever previously in either melting or moulding bronze, but he was full of energy and intrepidity—even rashness—and this seems to have been well shared with him by the commission of directors. He was, however, undoubtedly a man of much original resource and conception as to methods of moulding, and it was no doubt in a too fond reliance upon these, and upon plans for avoiding much of the cost of bronze moulding by previously employed methods, that he made his low offer which had been accepted by the directors. These methods De Launay actually carried out—we can scarcely say, with complete success—though his chief disasters arose from quite a different quarter.

He constructed reverberatory furnaces at the foundry—now fitted with new cranes, etc.—for the fusion of the bronze; but these were proportioned from his iron-founding experiences only, and proved splendid oxidizing furnaces, and with insufficient beds or "pools" and a cutting draft that swept away the zinc, tin, and lead at a rapid rate. Upon his demand the 1,200 guns were delivered over to him and stacked at the foundry, and an early proof of his rashness was afforded in that, to raise money, he at once sold or hypothecated the greater part of the 10 per cent. of the bronze allowed him for waste.

M. Darcét, well known as a chemist, by

his researches on alloys and other matters of technical chemistry, and then metallurgical director at the Mint of Paris, who appears to have been consulted in some way by the commission, foreseeing what a mess might be made of the bronze by improper treatment in melting, whether through ignorance or with fraudulent intent, strongly advised the director, Dénon, to have the bronze of the guns handed over, analyzed, and its mean composition fixed; also that some preliminary melting and moulding trials should be made, and the constitution of the resulting bronze castings determined, so that something like uniformity of alloy for all the castings of the column should be secured; and also that such methods of moulding should thus be arrived at and fixed upon as should insure a fine face to the castings, requiring little or no chisel-work afterwards at the hand of the chaser, and so that the eminent sculptors or modellers employed under Lepere upon the original models, should not hesitate to attach their names to the castings from their respective works. But true science, and the prudence she dictates, as so often happens, spoke in vain. The question of whether the guns should be assayed or not was referred to the decision of the founder himself by the commission; and De Launay, either seeing the possible advantages of leaving that point in the dark, or in pure ignorance, replied that "He did not need to be better informed than the administration, and saw no use in any analysis." So he set to work, and whether from vanity or a wish to impress his workmen, who proved for a long time very rebellious to his novel methods for moulding artistic bronze, involving wide departures from the time-honored processes which were traditional with them, he attempted at the first, several of the very heaviest castings of the plinth and base of the column, and with most of these it is said—with several it is certain—made complete failures, resulting in a serious loss in bronze, and alteration in its alloy, when thus requiring to be melted twice over. However, his method for moulding in dry sand all parts of the work—of which we shall presently write—had the advantage of great rapidity of execution as compared with the ancient modes, and the work soon went on apace, or, as we might more truly say in the vernacular, "ram stam." His furnaces, improperly constructed from the outset, and worked without skill and method, seldom gave two yields of metal alike; often the product was little more than red copper, the tin, the lead, and the zinc, having been oxidized out and raked away with the scoriæ, and often these had to be remelted with fresh tin or lead added, obtained by smelting operations conducted on the scoriæ themselves. The chasers and sculptors complained of the utter want of uniformity in the bronzes, as well as of the bad quality generally of the castings; but the work was permitted to go on until about two thirds of the total height of the spiral ribbon of relievos had been delivered, when De Launay found that he had scarcely any more material left wherewith to complete the work. His attempts now to smelt and return to use the mixed metals of low fusibility of the scoriæ resulted in the production of castings full of air-bubbles, and with segregated stains of lead; and the clever but rash man—accountable for all the material and for the completion of his contract—found himself, as it is commonly called, "ruined." And now at last M. Dénon and his *collaborateurs* were compelled to do what M. Darcet had advised at the outset. A commission of two chemists, two architects, two mechanicians, and two founders, presided over by an auditor of the Imperial Council of State, was appointed to investigate the whole matter and to examine the contractor's accounts. Their first act was to call for assays of the guns delivered over to, and of the bronze castings delivered by, the founder; but these were not to be had. The weight of each piece delivered by the founder was known; by taking specimens from all these in weight proportional to their weights, they obtained on analysis a mean assay for the whole of the column so far as completed; it gave as in No. 1:

	No. 1.	No 2.
Copper	89.440	89.360
Tin	7.200	10.040
Lead	3.313	0.102
Silver, zinc, and iron	0.047	0.498
	100	100

The like process gone through for the guns remaining unmelted gave a mean composition as in No. 2. It was obvious then that vast quantities of tin and zinc had been lost, and that very considerable

amounts of lead had been surreptitiously added in the meltings. Such, however, had been the irregularities of the earlier proceedings, that the commission was unable legally to make the founder amenable, and had, on the contrary, to admit that he had delivered an alloy richer in the more precious metal—copper—than that he had received. The extreme discrepancies in constitution between the castings was found analytically to be as much as from 6 per cent. to only 0.21 per cent. of the alloying metals, and in fact up to the date of its fall the difference in color and in *patina* between the castings were discernible by any technical eye. A curious contemporaneous contrast to this, as showing the difference between the rash "practical man" without science, and the combined effects of science and practice together, we cannot omit to mention. The guns taken in 1805–6 were so numerous that the French scarcely knew what to do with them. The huge bodies of the great screw and fly stamping presses of cast iron in the Mint had frequently broken, causing great inconvenience, and M. Darcét was given bronze guns enough to cast from them anew all these press bodies. They were cast in the Mint, and are there now, polished all over, without flaw or blow-hole; and M. Darcét had the satisfaction, when done, of presenting to his Government a report supported by analysis, and proving that the constitution of the press bodies was identical with that of the guns, and that far less than 10 per cent. loss had resulted from their fusion and casting.

By the long-handed-down methods for artistic bronze casting, probably as old as when Hiram cast the bronzes of the Temple for Solomon, "in the clay ground of the plain of Succoth," the moulds were produced in one or other of two ways, the mould itself being invariably of plastic tempered loam or clay, such as a brick is moulded from; viz., either by so moulding direct from the plaster model finished by the hand of the modelling artist, by means of a more or less complex assemblage of irregularly shaped "drawbacks," which, when fitted together, were themselves backed and supported by plaster of Paris; or from a modeller's wax model, which was itself either cast from the plaster model, or moulded direct by the artist, and which, after being completely surrounded by the loam, and that slowly dried, was raised in temperature in a stove until the wax all melted and ran out, leaving the mould empty and fit for the metal, however complicated or undercut in form. Those methods, however, are very tedious and expensive, require highly skilled moulders' labor at every stage, and when the casting is to be hollow, and therefore must be moulded on "a core," by no means secure against failure. De Launay obviously took his contract—judging from the account he has himself given—upon the strength of three *ideas*, original with him, and which he kept to himself until in the course of the work they became divulged, and as we have stated, were met with the incredulity and opposition of his workmen. First, he proposed to mould everything either in "green" or in dry sand. Secondly, he saw how he could mould direct from the plaster of Paris models, which he stipulated to have in duplicate, so that if one were destroyed he could himself replace it from the other one, and how he could extract these from the moulds, and yet avoid the complicated system of irregular shaped "drawbacks," at least to a great extent. Thirdly, he had a plan for ramming up the backs of the *bassi relievi* by something very like our modern system of plate moulding, viz., upon a thin sheet of softened copper beaten to the contour of the face of the model, or of a cast from it, and then stiffened by a backing of plaster of Paris, and after ramming upon this the sand of the second half of the box or *chassis*, cutting off from the sand, by hand, a sufficient portion from all parts that were square, or nearly square, to the face of the *basso relievo*, so as to give equal thickness to all parts. Our founder readers will comprehend this at once.

Now he was, in the man, right in all these previsions, and carried them all out. But it must be said he quite underrated the practical difficulty of carrying out his idea for the extraction of his plaster of Paris models. He based his plan upon these chemical facts—gypsum, or hydrous sulphate of lime, when burned in a kiln at a not very high temperature, loses its constitutional water and becomes plaster. When this is mixed with water to a paste, and has set, water is again chemically combined with the before anhydrous sulphate of lime, though it now assumes the

amorphous texture of a plaster image, in place of the original crystalline one of the gypsum. But this constitutional water, thus again taken up, can be again expelled in great part by a heat of about 500 deg. Fahr., or even less, and the coherent plaster then drops to pieces and becomes pulverulent. De Launay's plan then, was first to dry thoroughly and gradually his sand mould with the plaster model still within it, then to heat the entire to a sufficiently high temperature to cause the plaster model to lose its constitutional water, and then to pick out piecemeal the powdery or disintegrated fragments and leave the mould empty, and, after some dressing, fit for "pouring."

The plaster model of the cupola is right over—is the dome, in fact, of a cylindric brick oven beneath it. When the sand was rammed up all over it, a gentle fire first dried that, and then the heat being urged, the plaster model itself was destroyed and disintegrated, and the fire being let go out, the moulders got into the hollow of the oven, picked out the remaining fragments, and dressed the mould. The loam, or dry sand core, was made by the usual well-known methods, and when the "cope" was put over it the whole was ready for ramming up in the casting pit, and for reception of the bronze. In this, and in the use of the thin copper backs for the *relievos*, there was undoubtedly much ingenuity and originality, which in the hands of a less ardent and more prudent man might have been so modified as to have been attended with complete success. As it was, however, so rough and ill finished were numbers of the moulds thus prepared, and so bad the castings produced from them, that the artists and sculptors refused to permit their names to be cast upon the bronzes from them. The chasers finally employed to clear and make as perfect as might be the faces of the work, cut off to waste in the whole no less than 70 *tons* of bronze, which by their contract they were entitled to dispose of, in addition to which 300,000 fr. was paid them for their labor. The mismanagement of the whole affair strongly resembles the style in which our own public monuments, such as the Wellington one, and a good many others, are conducted, and the result is much the same in all. In the end, the French Government paid more for the Vendome Column, so economically contracted for at 5 pence per lb., than if they had given *carte blanche* to the first science and the ablest practice in the world for its production. But a strange want of constructive forethought marked everything about the work. It was predicted by the men of science, that if the bronze shell were rigidly fastened to the stone core of the column the effect of the unequal expansion and contraction of the bronze and of the oolitic stone-work would tear the latter, or possibly both, to pieces. Napoleon himself is said to have sketched a model for the *boutons*, which held the bronze to the stone, of a form leaving the longitudinal expansion free. The form actually, however, bound them together; and the effect was, that when the bright rays of a Paris summer's sun had struck for a long day upon the southern side of the column, a trained eye could see that it was visibly bent over towards the north. And again, when the radiation of a clear night's sky following, rapidly chilled the air, a current of heated air swept upward along the southern semi-circumference of the column and cooled the bronze with such rapidity that the evening visitor could hear distinctly the cracking noises produced by the settling down of the more or less shattered stone column as the bronze shortened and hung upon its exterior. Were it not for the shattering of the stone-work thus produced during 60 summers (it was inaugurated in 1810), it is doubtful at least that the awkward efforts of the *canaille* of Paris to pull it down would have been successful, though no doubt a very few pounds of gunpowder would have brought it down at any time. After Jena, the model of Charlemagne for the original statue had its visage modified into the features of the Great Emperor. It was modelled by Chaudet.

In 1814 the same sort of mob that recently destroyed the column, just then most loyal royalists, tried to pull off, by ropes, this statue, but could not succeed, and scaffolding and tackle had to be erected to lift it out of its *socle* or hollow base, and lower it to the ground, the *drapeau blanc* taking its place. It is said to have been melted up to re-edify parts of the statue of Henry IV. on the Pont Neuf. In 1833 Louis Philippe had a new statue of Napoleon, in his well-known gray riding coat and little cocked hat, telescope in

hand, modelled by Le Seur and erected on the top. The statue only weighed about 4 tons, and it was hoisted into place in 2 hours and 55 minutes from leaving the ground. It was secured in place by 6 bronze bolts, of which 3 were so arranged as to enable the perpendicularity of the statue to be adjusted to the satisfaction of the sculptor. The foundations of the column are those of the equestrian statue of Louis XIV., which, previously to its removal, stood in the Place Vendome ; but the surroundings were mean and paltry until 1835, when granite was brought from Corsica to form the still existing fine stone basement, and the bronze railing around, on which the *immortelles* used to hang thickly, was added, at a total cost of 76,000 fr. In 1865 the late Emperor Napoleon III. had a new statue in Roman military dress substituted for Le Seur's ugly figure, and this it is which now, headless and spat upon, lies desecrated on the dung-heap on which it fell. What a lesson, were any needed, of the insubstantiality and mutability of the most commanding power and greatness! And yet this has been surpassed by the worse than barbarian deeds enacted, while our ink is still wet, in the wilful destruction by fire of the grandest historic monuments, the noblest collections of architecture and of art, possessed by any nation. France has now indeed drank the cup of misery to the dregs. Even her bitterest foreign enemy must pity her condition. Comfort there can be none—even from those that love her best. The column, which was not Doric, as stated by the *Times*, but Roman Doric, was 44 metres high to the top. The total weight of bronze actually in it was about 252 tons ; so that, if all sold by the Commune, the old metal would not fetch more than about £2,000, and the money expended upon the monument from first to last, exclusive of the cost of its destruction, was in or about £95,000.

We have heard it stated in Paris society that the original plaster models were deposited somewhere in Government buildings, probably at the Musée de l'Artillerie. If this be so, there may be less difficulty in its restoration whenever France shall regain a Government, and Paris free itself from being rough ridden by its own worst mob. If once the original bronze of the guns that thundered in 1805 upon the Danube, and which now lies in fragments upon the pavement of the Place Vendome, had been sold by the Commune—and its being so was only a question of days—how should new and baser material replace it ?

ENGINEERING MATTERS IN TURKEY.

From "Engineering."

Turkey is a country of contradictions and a land of anomalies. Just as Mr. Micawber had an execution put in in the morning, and estimated the cost of a bow window in the evening, so you hear of the Turkish Treasury raising short loans, at 12 or 15 per cent., one day, and contemplating a great net-work of railways or half a dozen iron-clads the next. The explanation of this curious state of things is to be found in the vast undeveloped resources of Turkey. Turkey has wealth, if she would only turn it to account, and the Turkish Government seems occasionally disposed to act as if the empire were a rich and vigorous one; but the fact is overlooked that the resources of the country, such as they are, are undeveloped and unutilized, while the arbitrary character of the Turkish administration effectually checks and cripples any tendency to enterprise among the Turkish population, and a vague fear continually prevails that what is regarded as the traditional policy of Russia requires a continual expenditure in defensive armaments. The result of all these unfortunate circumstances is that Turkey does not take very kindly or successfully to the ideas and usages of Western European civilization, and that an enormous outlay continually prevails for warlike purposes, while the natural wealth of the empire is suffered to remain comparatively neglected. Nevertheless there are symptoms of improvement observable in Turkish affairs. Although, for instance, the Turkish Treasury is hampered with a chronic deficit, the revenue shows a tendency to improvement, and if the public expenditure could

but be kept stationary for a few years, something like an equilibrium would probably be established in Turkish finance. The Minister of Public Works has also mapped out a vast series of railway lines for Turkey in Europe; of this net-work, however, amounting to between 700 and 800 miles on paper, only the first section of less than 10 miles has been finished, and probably the works will not be pushed on very rapidly in the present condition of Turkish finance. It is satisfactory at the same time to observe that Daoud Pasha, the official at the head of the Public Works Department, has recognized the necessity of providing good common roads to serve as feeders to the Turkey in Europe railways. No less than 2,000 to 2,500 miles of roads of this description are to be made; they are to be divided into three classes, the cost being estimated at £1,250 to £1,562 per mile, according to class. Nothing probably would be found more beneficial than a good system of common roads, upon which road steamers would render very solid services until railways could be more extensively constructed. At present, from the unsatisfactory system of Government prevailing, the general depression in Turkish commerce, and the want of roads, Turkish railways have been serious financial failures for the most part, and the guarantees given upon them have only added to the embarrassments of the Turkish Treasury. The Smyrna and Aidin, for instance, involved a loss to the Turkish Government, in 1870, of no less than £96,814 on its guarantee account; and since October, 1870, the guarantee has not been provided for. The Varna and Rustchuk, another Turkish line, presents very similar results.

The great source of Turkish troubles, financial and otherwise, is, however, the heavy war expenditure which is constantly going on. At the Turkish naval arsenal, for instance, at Haskeui, an armor-plated corvette, the Moukaddem-Hair, is now approaching completion. The Moukaddem-Hair, which is a copy of a sister corvette designed by Mr. E. J. Reed, will be 235 ft. in length between perpendiculars, and she will have a belt of rolled armor-plating 6 ft. in breadth, and 6 in., 8 in., and 9 in. in thickness, more than half being below the water line. The corvette will be armed with four $12\frac{1}{2}$-ton 300 pounder Armstrongs, which will be shortly received at Constantinople from Sir W. G. Armstrong & Co. The battery in which these guns will be mounted will be octagonal in shape. The plates used in plating the corvette have been rolled at Haskeui, which has also turned out all the other iron required for the ship. The plates are 16 ft. in length and 3 ft. in breadth. The burthen of the Moukaddem-Hair will be about 1,600 tons, and she will be fitted with engines designed by Mr. Shanks, and working up to 3,250-horse power, although of only 500-horse power nominal. Haskeui is engaged on two other pairs of engines of 60-horse power nominal, which are being made for two gun-boats, two stationary engines of 25-horse power, and four pairs of floating fire-engines. A new smith's shop to contain 50 fires is also being erected, and drawings have been prepared for the erection of some large factories and foundries, to replace others at Yali-Kiosk, the site of which has been given up to the Roumelian Railway Company for a Stamboul terminus. The Taif and Sharki-Shadia paddle-wheel frigates have received new engines and boilers; and two iron-clad monitors, purchased in France during the Cretan insurrection, have been reconstructed so far as their defective armor plating is concerned. Rope-making machinery has recently been supplied to Haskeui by Messrs. Fairbairn & Kennedy. Altogether, Turkey shows considerable vigor in the matter of her navy, which seemed to be regarded as a formidable one by Earl Granville in the House of Lords on a recent occasion; the crews are not so efficient as the ships, but Turkey would appear to be dreaming of the day when she will try her naval strength with Russia. A Cretan journal refers to the progress which has been made with a new naval arsenal at Souda Bay; slips for building and refitting vessels, which have been for some months in progress, are now finished, and workmen were engaged at the last dates upon a commodious barracks for sailors. The construction of a large dry dock is also to be commenced. Here we have another indication of the resolute intention of Turkey to become a naval power. The characteristics of the Turk would appear, indeed, to be unchangeable. He borrows readily enough of the Frank, and he pays his way as well as he can, and professes a scrupulous good

faith. But still the old nature is strong within him. While Turkey has scarcely any roads, while her railways are few and incomplete, while her harbors require improvement, while her mines are unworked, no small slice of the public resources is spent upon war purposes and war objects. However, sounder ideas will probably gradually gain ground, and we are glad to see that in the case of the now profitless Varna and Rustchuk Railway, the improvement of Varna harbor is occupying the "serious attention" of the Turkish Government. Some consideration has also been devoted to a great bridge over the Danube, at Rustchuk, which would connect the Varna and Rustchuk with the whole system of European railways. Works such as these would prove more profitable to Turkey than monitors and iron-clads. Still, Turkey can scarcely be expected to submit passively to any ambitious designs which Russia may cherish; and she certainly will not do so, for Turkey has traditions quite as powerful as any which can actuate her old antagonist.

THE METRIC SYSTEM.

Prof. Chas. E. Davies, of West Point, delivered a lecture at the Cooper Institute, on the 29th ult., on the metric system and the probable consequence of its introduction into this country. After explaining the system in detail, he concluded his remarks as follows :

Let us suppose the metric system to be adopted by law, and every other system excluded—for, without such exclusion, the whole thing would be a perplexity and a farce. What follows ? We have blotted out from the mind of the nation the foot and all knowledge of every measure into which it enters as a unit. We have expunged the yard, used in connection with the arm, more or less in every family; and the pace, the unit and guide to the farmer for an approximate measure that will not supply the place of either. Every lot of ground 25 ft. front by 100 ft. deep must be described as follows: 7 metres, 6 decimetres, and 2 centimetres, front, by 30 metres, 4 decimetres, and 3 centimetres deep. Thus, the decription of every such lot will require 3 different units and 6 words, instead of 1 unit and 2 words. In all conveyances and descriptions of land, the translation from one language to the other would occasion great trouble and difficulty. The old familiar mile of 1,760 paces is also gone; and the distance from Albany to New York, 145 miles, will be known to us, if known at all, as 229,680 metres. Let us see how we shall recognize the earth in its new dimensions. Its diameter, instead of 8,000 miles in round numbers, will be 12,672,000 metres, and its circumference about 39,810,355 metres and 2 decimetres. The acre is also gone, and with it all its multiples and sub-multiples. Since the commencement of the present century the public lands have been surveyed and laid out in townships of 6 miles square, each containing, of course, 36 square miles, or 23,040 acres.

The side of each township, by the new system, would contain 9,504 metres (instead of 6 miles), and its area 921,600 *ares*. All the lands from the Ohio river to the Pacific Ocean have been surveyed, deeded and recorded in the units of the sq. mile and the acre. What will be the labor and the confusion of translating every deed and every record into the language of the metre and the are ? We should scarcely know our own farms by their new names.

If the introduction of the metric system produced only a change in the names of the units, leaving their values the same, or, if it altered the values only, preserving their names, the difficulty would be comparatively small. But, unfortunately, we must change both ideas and words—the foundations of systems and the language by means of which these systems are developed and made known. These double changes, made at the same time, are very serious, because there is no thought or word in one language having an exact synonym in the other. The consequence of these changes to the metric system would be the following :

1. They would strike out from the English language every word and phrase and sentence used in connection with our present units of weights and measures, and would impose the necessity of

learning a new language for the one now in use.

2. They would blot out from the knowledge of the nation all apprehensions of distance, and area, and volume, acquired through the present units, and would render necessary the acquirement of similar knowledge by less convenient units, having different relations to each other, and expressed in a new and unknown language.

3. They would change the records of our entire landed property, requiring them all to be translated into a new and foreign language.

4. We must not forget that prices and currency are dependent upon, and necessarily adjust themselves to, weights and measures, and that all our ideas of cost and value are fixed with reference to our present units. The adoption of the metric system, therefore, would carry with it an entire change in the money values of all artices of commerce and manufactures, and of all agricultural productions; for these values would have to be readjusted to the new units, and to be expressed in the new language. Hence the changes would extinguish all knowledge of money values, now so familiar to the entire population in their daily purchases, and sales and barters, for those values are all adjusted with reference to the units of weights and measures.

5. Can we afford to make these changes for the very small gain of changing our present yard from 36 in. to 39 in. and 37-100 of an inch? Can we accept any system as a substitute for the one now in use, unless it makes some provision for retaining the unit 1 ft.?

All our knowledge of distances, the yard, the rod, the furlong, the mile, the league, come from it. The square rod or perch, the rood, the acre, are also derived from it. Can we change the survey of an entire continent, with the description of every piece of land upon it, from the unit, one acre, to the unit, one are, 40 times less? Can we change, without great confusion, the unit of volume, the cubic foot, and the cubic yard, so familiar to every school-boy? and, above all, can we change our unit of weight, the pound avoirdupois, which is equal in weight to 16 of the 1,000 equal parts of a cubic foot of rain-water?

6. Can we abandon, as a mere question of language, these short, sharp, Saxon words, for their equivalents expressed in a foreign language? Besides, the foreign language which we introduce has no exact equivalents to these words, which have almost become things, and which now form a part of the mind and knowlege of every people who speak the English tongue, or are connected with the American commerce. These are the great questions now discussed and considered by the American people. They affect directly the interests of all classes. They affect our systems of public instruction, our trade, our commerce, and the mechanic arts, in all their development, and in all their applications. Let us, then, approach these questions with a deep sense of their importance. Let no hurried action embarrass us. Let us remember that time is a necessary element in the accomplishment of everything that is truly great, and that these questions can only be rightly and permanently settled by the enlightened and aggregated judgment of mankind. Let the discussion, therefore, be full and complete.

METALLIC CARTRIDGE CASES.

From "The Engineer."

At a recent meeting of the Gunmakers and Inventors' Club, a paper was read by Mr. F. Osborne, on "Metallic Cartridge Cases." Mr. Osborne stated that he would not go into the history of metallic cartridge cases, commencing as they did with the tiny capsule for saloon pistols, introduced by our French neighbors, and itself only a large percussion cap, which was subsequently developed into the flange or rim-fire copper cartridge so much used in the United States. Some ten years ago the cartridge began to give way to the central fire cases of Potet and Schneider, the latter having a folded metallic base, strengthened inside by a thick wad of compressed paper, and an anvil, or short pin, inserted in the base, on which the cap was exploded. These cartridges were made originally for sporting purposes, with a

shell of rolled paper, or millboard, and we may consider them as the type of all the central fire cartridges now in use. No advance has been made so far as the principle is concerned, but very great improvements had to be made in the constructive details before an efficient cartridge for military purposes could be produced. Such a cartridge must have strength to stand a very heavy charge of powder fired out of a rifled arm, the force of the explosion being immensely increased by the resistance which the latter offers to the bullet. It must be capable of easy extraction, waterproof, and not liable to be injured by rough usage. If the case can be refilled and used several times, it is an undoubted advantage, although a good deal of special pleading has been employed to prove that such refilling is of little or no consequence. The first cartridge that came near to fulfilling these conditions was the "Boxer," which, when first introduced, differed from the above-mentioned sporting cartridges in having its shell of coiled sheet brass, with or without paper covering. It was at first a failure, but having had the advantages of a long and somewhat exceptional course of experimental treatment at Woolwich, extending over several years, and having there received various additions and improvements, it arrived at the state in which we now find it. As a cartridge for the Snider rifle it is in its present form perhaps as good as any other, and even as a small-bore cartridge it is very efficient so far as shooting is concerned, but owing to its great length (now 3¼in.), coupled with the extreme thinness of the metal coil, it is liable to distortion, and a little rough handling renders it unserviceable.

When it became clear that the small bore was to be the arm of the future, an attempt was made to get over the difficulty by making the cartridges of bottle shape, and a cartridge of this shape has been decided on for the Martini rifle. The bottle form of cartridge, particularly where the difference of diameter is as great as exists in the Boxer, is bad in principle, and only adopted as a means of getting over what is a radical defect in the arm, the inability to use a cartridge of any length, which future experience may prove to be the right one. With a cartridge of this form, as compared with the long small bore, the strain on the breech action is increased more than one-third. With some bottled cartridges the strain would be doubled, owing to the area of the cartridge base so far exceeding that of the bore of the barrel. The recoil is also increased, but not in the same proportion, or for the same reason, but owing to the sudden ignition of a short column of powder. The long thin cartridge requires more time for its complete combustion, and starts the bullet gradually without unduly "upsetting" the same. In fact, the length of the cartridge here serves the same purpose as the use of pebble powder in heavy guns, by which an increased velocity of bullet is obtained with only half the strain on the gun. The sudden ignition of a short column of powder in a part of the barrel doubly weakened by the enlarged chamber and the screw outside, is thus contrary to all the principles of gun construction. Whether the Boxer cartridge is made in the cylindrical or bottle form it is liable to four objections. First, the excessive weakness of the shell; second, want of capacity, owing to so much space being taken up with the paper wad; third, complication of parts, which, while it somewhat facilitates construction, is opposed to uniformity, an error in any one of the parts being sufficient to vitiate the results; fourth, the base, being attached by riveting at the centre, is liable to be pulled away by the extractor, and sometimes pulled off. The last objection has been got over, to a great extent, by using a very thick base. With a view to produce a cartridge case free from these objections many experiments have been made, both here and in the United States, involving an immense expenditure, on account of the great mechanical difficulties to be encountered; for it was determined from the commencement that the cartridge should be of one single piece, that there should be no makeshifts or cobbling-up of weak places, no dependence on paper wads or separate anvils, which last were occasionally left out. These attempts could hardly fail to succeed, and now the solid metallic cartridge cases made here and in the United States leave little to be desired. The cartridge cases which for the last two or three years have been made at Bridgport, Massachusetts, are almost perfect, in finish they have never been surpassed. They are made from a

single piece of metal, up to $2\frac{1}{4}$ in. long, are capable of containing 70 to 75 grains of powder, and may be refilled several times. The shell is exceedingly strong, of bottle shape certainly, but not nearly so marked in this respect as the Boxer. The only drawbacks upon them are that they have not sufficient capacity for the large charge of powder we are in the habit of using, and that they are sometimes found to open at the folded base. For the last two years strenuous efforts have been made in this country, or rather Birmingham, to improve upon these, and I think I may safely say that these efforts have been crowned with success, and that a cartridge is now being made here in large quantities which is almost as perfect as any cartridge can be, as, with all the advantages of the last, it has a capacity for 85 grains of powder, and has a base not folded over as in the Bridgport cartridge, but formed out of the solid metal. The first cartridges made on this principle were not of so good finish as the American, owing to the greater novelty of the manufacture in this country; but this defect is fast disappearing, if it has not disappeared already. These cartridges may be reloaded a score of times. As the Boxer has been distanced by the Bridgport, the latter has been beaten by the new solid-base cartridge here being made. The reading of the paper was illustrated by a large collection of cartridge cases, showing the progressive stages of invention, most of the cases in section, to show the peculiarities of construction. A discussion took place after the reading of the paper. Mr. Whitehill, who has had a large experience in the manufacture, was of opinion that the folded base was sufficiently strong, if the cartridge chamber was made with sufficient care. He had fired individual cartridges more than twenty times without the slightest difficulty in extracting after each discharge. Mr. Mabbutt considered that many difficulties would be avoided if the gunmakers and cartridge makers were to come to a better understanding with each other, and asserted that if cartridge makers were to determine not only the dimensions of their cartridge, but also the amount of clearance required, there would not be the slightest difficulty in chambering the guns for them so as to produce perfectly uniform results.

ON THE ARCHITECTURAL TREATMENT OF PORTLAND CEMENT.*

From "The Building News."

I am well aware that I am about to tread on very delicate ground, and that in presuming even to suppose that Portland cement is a material that it is possible to treat architecturally, I fear I shall be out of sympathy with the great majority of the members of the Association. The best architects, as a rule, entirely ignore this material, and many would regard it as a sign that a man who uses it habitually and especially as ordinarily treated) is necessarily a man who does bad work. I confess I myself share that feeling to a very considerable extent. The prejudice that exists against the use of Portland and other cements as an external covering is, I believe, one that has arisen more from the abuse of the material than from its fair use. Unfortunately, it seems to have been one especially patronized by that large and energetic body of men who have covered the whole of the suburbs of London with dwellings alike bad in construction, in internal arrangement, and in external appearance. I need hardly state that I refer to the class known as "speculative builders." I regard as one of the greatest misfortunes that could happen to any community the being obliged to depend upon the production of such people for the dwellings and homes in which, as a rule, the most enjoyable part of existence is passed. However, so much has been said and written on the miseries and discomforts of "speculative-built" houses, that I need not occupy your time by enlarging on this matter except as regards its direct bearing on the subject of this paper. In my opinion Portland cement has been unfortunate from the date of its first use, and even in its name (so-called from its supposed resemblance to Portland stone), it indicated a departure from the first principles that should have guided its

* A paper read before the Architectural Association by Mr. Rowland Plumbe, F. R. I. B. A.

proper use ; for the very thing that was wanted in its proper employment was that it should not look like Portland or any other stone, and that it should stand and be treated as a material of itself. My sympathy with the use of this material arises to a great extent from a consciousness of the ill-use to which it has been subjected by Mr. Stucco and his friends and relations the speculative builders, who, having once decided on its being a material well suited to embellish their productions, seem to have had no difficulty in persuading the surveyors of the estates on which they were building that it was a material that could make the designs of their house fronts look like the most beautiful stone-built houses ; so they thereupon set to work, and in the most lavish and extravagant manner they built and constructed —and even to the present they build and construct—their semi-detached villas (letting at the enormous rents of from £30 to £50 a year), with cornices copied direct (with slightly exaggerated proportions) from the Italian palaces and even Classic temples, as set forth in the various architectural drawing-books to which they have access, or as handed down from generation to generation in the shape of old moulds and other stock in trade. Obviously, to people of such proclivities the temptation to put to their house a cornice fit for a palace must be very great, when we consider that the difference in expense between it and an appropriate one consisted principally in the cost of preparing the zinc mould used to run it. Why shouldn't they have a grand palatial cornice, they say, when it doesn't cost more than any other ? In like manner they have proceeded to decorate their windows with most elaborate dressings, and their doorways with massive columns, each looking as though worked out of one stone, and with richly carved caps and entablatures. Indeed, some go even so far as to cover the whole surface of their houses with cement, jointed in the most perfect and regular manner also, to look as though the houses were built of solid stone, until the unsuspecting British householder becomes so amazed at the great architectural advantages thrust upon him, that he cannot do otherwise than purchase the "eligible semi-detached villa residence, with pleasing elevation," so often and so successfully offered at a price so infinitely below its apparent value, it having to be pretty plainly intimated that the architecture has been thrown into the bargain for nothing, entirely out of the love and regard which the said Mr. Stucco and his friends have for really good work and fine art. But, alas! the illusion passes away. In addition to the discomforts which bad construction, faulty arrangements, and worthless fittings produce, insult is heaped upon injury, and the British householder finds the pride of his heart, the palatial front, showing signs of decay. First, a suspicious swelling appears in numberless small places over the front ; then the solid stone ashlaring begins to turn up at the edges ; and after a time it peels off, as though suffering from some leprous disease, and leaves exposed underneath a hideous surface, seemingly compounded of dirt and cinders, until shortly the elaborate dressings and massive columns and entablatures also begin to show signs of decay, and each morning as the too-confiding possessor of the palatially-fronted residence takes his departure for town, he is cheered by the sight of its mangled remains strewing the ground as he walks away. Still, with the courage of despair, he determines not to be beaten, and sends for Mr. Stucco. If he does succeed in obtaining an interview with that gentleman, as a rule the result is not satisfactory. Nothing remains to be done but to send for a really respectable builder. No doubt *he* will soon put all matters quite straight, and the house will be restored to its first beauty and grandeur. The workmen make a commencement, and for a time the proprietor hopes he has seen the worst of his bargain; but the workmen do not seem to be making satisfactory progress with the work ; more and more of the solid stone ashlaring and elaborate and massive architectural features have to be removed ; and, to make a long story short, it is found that cement work of the worst possible quality has been plastered over as a screen to conceal brick work as bad and rotten as could possibly be built. Then the proprietor knows the worst, and probably tries to patch up his front as best he may ; and in the event of his not being able to sell the house, makes up his mind to spend a considerable amount every year or two in repairing that which can never be made sound, as from its construction it must

necessarily be subject to continual dilapidations.

Now, in the face of extensive experience of cement work of this description (and no doubt most of us have met with such cases continually), can it be surprising that we should have conceived a prejudice against the use of the material itself? Bnt, surely, when architects themselves use Portland cement and other similar materials as an external covering, the beforementioned disqualifications to its use do not exist? As a rule they do not. What, then, is the objection to its use? Here I must confess that we as architects have much to answer for in this way. In most cases where cement is used we deliberately sit down and design a front, frequently exercising much care and thought, and often showing great ingenuity and merit; but we design it in every way as though it was to be built of carved and worked stone, and then, as though suddenly awaking to the fact that even our most sanguine expectations of persuading our client to make the necessary outlay to carry it out will not be realized, we resolve to carry the whole out in Portland cement.

Now, designing and working in this spirit can we expect to obtain good results? Are we treating the material fairly? In fact, are we doing better or truer work than Mr. Stucco before so often referred to? To all these questions I answer emphatically, No! And until we can divest our minds of the delusion that stone forms and treatment can be properly carried out in cement, we shall never design properly in the latter material. It may possibly be contended that an architect who designs a building well and carefully, and one which possesses originality and power, and that it is in every way appropriate and suitable for stone construction, is entitled to as much credit for his design, even though it be carried out in cement, as would have been accorded to him had it been executed in stone; and it may further be argued that it is not the architect's fault that it is not executed in stone, but that his client is compelled to adopt the less expensive material. I venture to think, however, that this is an untrue and dangerous view to take. There cannot in this case be a mere beauty of architectural form and combination irrespective of the material with which we have to work and in which we have to design, and in such case if an architect cannot carry out his design in stone he must not hesitate to make a fresh design suitable to the less costly material with which he has to deal. Serious errors in this respect, have, I think, been made by architects of great reputation (who have carried out large and important works in magnificent positions) through working in the untrue spirit to which I have above referred. With the greatest deference to the talent and ability of these gentlemen, I cannot help saying that in my opinion they have lost great opportunities, and that if, when designing in cement, they had studied to employ combinations suitable for the material instead of the stone forms used, they would have produced infinitely truer and finer buildings, and would at the same time have increased their own reputation and advanced the cause of architectural art. Let us most rigidly and unhesitatingly admit as a canon of architectural art, that the designer must above all things, in the conception of his design, consider the material he is about to use, and then I venture to think that we shall soon have an architecture, even of Portland cement, as true and as appropriate as the architecture of any other material. It may fairly be said that the principles I have been advocating apply to the design of all materials, and are in no way peculiar to the treatment of Portland cement. Of course this is unquestionably correct, but I think I am not wrong in stating that of all materials, that which has received the least consideration as regards special design is undoubtedly Portland cement used externally. There can be no doubt that good cement work is in many instances a most valuable and durable material regarded in a constructive point of view—so much so that in most of our seaside towns, and in positions exposed to the driving, penetrating rain that so often accompanies our south-west winds, it has got to be almost universally used, and has been found frequently to be the only material that will resist the penetration of damp, it having often been used successfully when all other known precautions (such as hollow walls, etc.) against the penetration of weather have failed.

The growing use of concrete construction renders it extremely probable that Portland cement will be more extensively used as an external covering, it having

been found necessary, in most cases, to cover the concrete walls with cement. Being now engaged professionally in the carrying out of a rather extensive range of buildings in concrete, I find myself compelled to grapple with the difficulties of Portland cement design; and it is only in connection with frame-built concrete buildings that I personally should feel disposed to use cement architecturally. I should certainly infinitely prefer to design a brick building as such, than to cover it with cement, unless very special circumstances rendered it desirable to do otherwise.

Having stated rather fully how cement should *not* be used, it is now necessary to indicate how properly to employ it. In doing this, I purpose endeavoring to point out some of the principles of design which seem to me peculiar to it. I do not consider it within the scope of this paper in any way to touch upon practical subjects, as the quality, strength, and proper working of cement. I presume you will all admit that the material is one thoroughly fit for the architectural treatment to which I allude, and that, when of good quality and properly worked, it is durable and suitable for its purpose.

Firstly (and chiefly), I would submit that Portland cement should no more be treated as stone than it should as wood, or any other material of equally different nature. It should be treated exclusively and entirely as a plastic material, always remembering that it is a comparatively thin coat laid over and upon some other material forming the bulk of the walling, it being generally presumed that it is of superior hardness and durability, and more water-proof than the material it covers, and that to that extent it is intended as a protection and preservative of the same. This, it seems to me, would indicate that it should be treated with great breadth and in large surfaces. I should certainly be exceedingly careful how I broke up the surface, and should always endeavor to treat it as a covering laid on, and to preserve a flatness and absence of everything like high relief and deep sinking. Carrying out the idea of its being a plastic material, I should not object to run such mouldings as could be obtained in the thickness of the cement itself; but I think care should be taken to keep the mouldings as fine as would be done in designing any other plaster work, such, for instance, as would be employed for inside cornices and similar plaster features. Anything like elaborately moulded and blocked cornices, requiring stone cores and other artificial means of obtaining projection, should be avoided; but if it were necessary to project walls or to use a cornice, I would prefer to use such as could be run on any projection that could be obtained in the material of the walling itself. For instance, in the concrete building I am erecting, I bring over the walls as a shallow cove at top, and I purpose covering the same with colored cement, adding one or two shallow mouldings, such as can be got in the thickness of the cement. Anything in the shape of architraves, pediments, or other dressings to window and door openings, should be avoided; but good effects might be got by forming splays and running shallow mouldings round the reveals. Jointing or lining the surface, as usually seen in stucco work, should be avoided as an imitation of stone jointing, and as destroying breadth and flatness of surface; but incised lines and ornament of shallow depth may well be employed to obtain richness of effect and to cut up the surface without destroying the breadth. The true treatment of cement-work would probably lead to a more extensive use of these narrow sinkings, both in lines and ornament, and such a treatment would be legitimate, as they could readily be run and worked in the cement.

The texture of the face of the work is of importance. If finished off, and floated with a wood-float, the *sand* is brought very much to the surface, and a rough texture is given to the work, that being generally the surface now given to cement-work as usually executed. The advantage of this rough surface is doubtful, especially in London. It soon discolors, and there is but little chance of its washing clean with the weather. An exceedingly fine—almost polished—surface can be given by finishing with a steel float or trowel; in this case the cement comes to the surface, but is apt to show the working of the trowel, and to leave a smeared surface, far from sightly or agreeable in appearance. The surface that would probably meet with most approval is one which may be described as between these two, and is obtained by floating with a steel trowel, but by finish-

ing the process by dabbing it on the work instead of floating; this gives an exceedingly hard surface without the excessive polish obtained by the last method, and is so much finer than the floated work that it would probably retain its color much better.

Of course it is highly desirable to avoid painting cement-work, but at the same time the atmosphere (and that of London particularly) will discolor it after it has had some years' wear. I have but little doubt, however, that it could be cleansed from time to time at no more expense than would be incurred by staining and tuck-pointing brickwork and by scraping stone-work, as is usually done in cleansing these materials. Particular attention should, I think, be given to the local color of the work. As a rule, Portland cement mixed with Thames sand does not give an agreeable color, but it may be varied by mixing with different colored sands, from white to deep red. The specimen on the table [shown] is made with a mixture of Thames and White Leighton sand—one of each and one of cement; and a mixture of cement and burnt ballast and sand gives an exceedingly good warm color.

Cement work is particularly well adapted for colored decoration, and with proper management and careful design in its use I believe exceedingly good results might be obtained. The cement should be colored before working, as its effect is entirely different from any coloring put on after the work is set. So important do I consider this part of our subject that I should like to see every cement-designed building treated in color. Here are some specimens of colored cements on the table, all of which (with the exception perhaps of the yellow) might be used in external decoration. [Specimens shown.] All kinds of colors will not mix with cement; some kill it, others are themselves destroyed by admixture with it. As a rule, mineral colors will stand best. Of the specimens on the table, the dark red is made of one-tenth part of purple brown (oxide of iron), 2 parts of sand, and 1 of cement, all mixed dry before making up for use; the light red is made with Venetian red, in the same proportions; the blue is made of German ultramarine, mixed as before; the green is obtained by green ultramarine, and this, by daylight, is of an exceedingly nice tint—the color, itself, however, is expensive, so much so as to render its use in large quantities somewhat improbable—the proportions are as before; the yellow is made of cadmium yellow and Thames sand; brighter colors might be obtained, but it is hardly a color that could be used in decoration to any extent unless mixed with others. Good blacks might be made with black manganese mixed in the same proportions. All these colors could be varied by altering the proportions and by using different colored sands. The admixture of colors with cements no doubt will give different results as regards setting and color, varying with the cement and sand used; before employing the same, direct experiment should therefore be made. This facility of mixing color with cement is, I feel, a strong point in its favor, and should be fairly tried by all interested in or using cement architecturally.

In connection with colored decoration in cement work, encaustic and other tiles might be used with great effect. The tile work that I have seen in connection with cement has not seemed to me to be satisfactory in appearance. Highly-glazed tiles are usually employed, and the effect, in conjunction with the dull floated surface of the cement, shows too great a contrast. If the cement surface were finished as before last described, and the tiles were not to be glazed, the effect, I feel sure, would be extremely good. The small self-colored tiles might be used with excellent effect as bands and lines instead of incised work, or even as a mosaic in panels or friezes. I should, however, prefer to have them unglazed. The manufacture of ornamental tiles has reached so high a pitch of excellence, the variety of design and color is so great, the texture and color of the cements may be made so suitable, and the fixing is such a simple matter, that I think every inducement exists for the employment of the two materials together.

Cement work may be ornamentally treated by a kind of stencil process, which is almost as rapidly executed as ordinary paint stencilling, and it can be done by experienced workmen almost as cheaply. A stencil plate having been cut to the required pattern, and of the necessary thickness (according to the relief wanted), it is laid over the ground, when the latter is sufficiently set to allow of its being worked; but as soon as possible after the

general surface is laid on, colored cement, or, of course, the same colored cement as the ground, is then filled into the perforations of the plate, and floated off flush with its upper surface; the plate, on being removed, leaves the pattern as shown in the specimens on the table. If the ground is roughed for an extra "key" to the stencilling by picking through the pattern of the plate before filling in, great extra durability results, and, as the ground is hardly set, the stencilling sets and hardens with it, so that a most durable kind of ornamentation is obtained. This plan could be adopted to any extent, and pattern over pattern might be stencilled, and different colors might be used to the extent of many layers, as shown in the specimen on the table—[showing a green ultramarine ground colored with various colored cements filled into a second stencil plate.]

A perfectly legitimate method of enriching a cement surface would be to stamp thereon patterns in bands, or as a diaper in low relief as it is setting, and unquestionably the result would be satisfactory. Enriched surfaces of this kind, using different dies, and doing the work by hand, so as to give a slight variety of texture, could not fail to have an exceedingly good effect. Metal dies with polished faces would give the best results. Some time ago Mr. Ferrey, in a short paper read before the Institute, advocated this method of decorating the ordinary stucco work of churches and other buildings. I am not aware if he has employed it, nor can I say whether in stucco the effect he expected to obtain was gained. I have no doubt, however, that such a method could be employed in the treatment of a cement surface.

A much more elaborate and expensive method of ornamenting cement surfaces has been to my knowledge employed with a view of its being used as flooring. The pattern or patterns were cut out of the cement when set, and colored and stamped patterns filled in, the general surface being ground to preserve its color, but all attempts to bring it into use were abandoned, on account of the great cost involved in its manufacture.

I imagine that all the processes used in the ornamentation of old plaster work, and known as "pargetting," might with equally good effect be used in the treatment of cement fronts, and that wrought and stamped devices might be used in almost an exactly similar manner, and also that various patterns and ornaments might be worked in a different-colored or different-textured material, much in the same manner as in the old work. Much information and many suggestions for the treatment of cement fronts may be obtained from a careful study of old plaster work. All fresco decoration and other artistic painting on cement surfaces is itself a distinct art, which it would hardly be within the scope of this paper to consider.

Cement surfaces may also be ornamented by hand with a trowel-point, or with a pointed lath, the patterns being scratched on the surface much in the same way as is often to be found on old plaster work, and as revived by Messrs. Shaw, Nesfield, and others. A specimen of this work can be seen on one of the most charmingly-designed lodges I have ever met with; I refer to the lodge at the southern end of the Broad Walk in the Regent's Park. The best art work might be produced by hand in this way at but a comparatively small expense, and colored cements might advantageously be used with them.

My paper will probably hardly be considered complete unless I take some notice of cement cast work. Of course I should entirely eschew the use of cast work in all forms properly belonging to stone treatment. The use of the wonderful capitals and ornamental brackets that are now so much employed would demoralize the effect of (in other respects) the best-designed cement building; but cast work might perhaps be permitted in such positions as might be suitable for encaustic tiles, or series of geometrical patterns in bands and small panels. Personally, however, I should try to avoid its use, and depend upon some one or more of the processes before indicated for my effects. All hand-modelled work on the building itself could, of course, be used, although in so quickly-setting a material there is not much scope for any elaborate work of this kind.

In conclusion, I am anxious to impress upon this meeting that I do not advocate the use of Portland cement architecturally; I consider that we have other materials which we can use to much better advantage; but I do wish to point out

strongly to the members of this Association the fact that we, as artists and architects, must, whenever we are compelled to use it, endeavor to our utmost to give it a suitable and distinctive treatment.

EXPLOSIVE COMPOUNDS—ESPECIALLY DYNAMITE AND NITRO-GLYCERINE.

From the "Journal of Applied Chemistry."

Lieutenant Trauzl, of the Austrian Engineer Service, has prepared a useful manual on the comparative value of gun-cotton, dynamite, nitro-glycerine, and other explosive compounds; a translation of a portion of which by Mr. Elywn Waller, of the Columbia College School of Mines, we find in the "American Chemist" for May, 1871. As we have not the original pamphlet before us, we shall make free use of Mr. Waller's admirable translation. Lieutenant Trauzl points out some of the leading defects of gunpowder as follows :

1. Difficulty in obtaining a uniform product. 2. Danger in manufacturing, working, storing, transporting, and applying it. Sixteen per cent. of the powder mills in France are said to blow up annually. 3. Deterioration from age and transportation, due to pulverization and exposure to moisture. 4. Inferior explosive power disproportionate to the requirements of the civil and military service. 5. Difficulty of employing it under water. 6. Noxious character of the gases produced by the explosion.

The author then gives an account of the experiments conducted in Europe to test the merits of gun-cotton and other explosives. The French Commission of 1846 reported unfavorably to the application of these materials, as having no advantages over gunpowder then in use. In England experiments conducted up to 1854, led to a report of a similar tenor. The Prussian trials for military purposes, instituted at Mayence, were interrupted by the revolution of 1848, and the Government finally abandoned the idea of introducing gun cotton into the artillery service. Austria has clung to the proposition to use gun-cotton longer than the other nations, for the reason Baron Lenk introduced some improvements in its manufacture, and the commission appointed to investigate the subject, reported that the improved article was superior to gunpowder for use in artillery, hand-grenades, shells, military mines, and blasting. In consequence of two fatal explosions in 1862, a second commission was ordered to investigate the subject, and they reported that gun-cotton did not possess the necessary stability for use in military operations. There was still a limited use for shrapnels and engineering purposes, until a more destructive explosion in 1865, practically put an end to its use in Austria. In 1864, Nobel, a Swedish engineer, brought nitro-glycerine into notice, and about the same time a powder, composed of picrate of potash and nitre, was invented by Designolle, a French chemist. This latter powder was not favorably received at the time, but during the recent siege of Paris, it has been employed to great advantage.

NITRO-GLYCERINE AND ITS MIXTURES.

The method of making nitro-glycerine, as practised by Kopp in the department du Bas Rhin, is as follows : Fuming nitric acid of 40.50 deg. B., is mixed with moderately concentrated sulphuric acid in a sandstone jar surrounded with water, in the proportion of one part by weight of nitric acid to two of sulphuric acid. Then commercial glycerine, which must be quite free from lime and lead, is evaporated down to 30.31 deg. B., and cooled ; 3,000 grammes of the mixture of acids is then placed in a suitable vessel, which is kept cool by some artificial means, and 500 grammes of glycerine run into it, with frequent stirring. The temperature should not be allowed to rise above 20.30 deg. C. The mixture is allowed to stand from about 5 to 10 min. after all the glycerine has been added, and then 5–6 times its volume of water added. The nitro-glycerine settles at the bottom, and can be readily washed by decantation until the wash water gives no acid reaction to litmus paper. To render nitro-glycerine unexplosive while being transported, Nobel dissolved it in methyl alcohol (wood

spirit), which may be made to precipitate the nitro-glycerine, when it is required for use, by dilution with 6–8 times its bulk of water. This method is somewhat objectionable on account of the volatile nature of the methyl alcohol. When frozen it must be thawed out in warm water.

DYNAMITE.

Nobel invented dynamite, which is a mixture of 75 per cent. of nitro-glycerine with 25 per cent. of infusorial silica. The silica renders the powder less liable to explode from concussion. This is the dynamite proper, but dynamite is also used as a generic name for other mixtures of nitro-glycerine, as colonia powder, which is gunpowder with a mixture of 40 per cent. of nitro-glycerine ; dualine, which contains 30 to 40 per cent. of nitro-glycerine mixed with sawdust saturated with nitrate of potassia ; lithofracteur, which contains 35 per cent. of nitro-glycerine mixed with silica, and a gunpowder made with nitrate of baryta and coal.

LITHOFRACTEUR.

Lithofracteur is composed of—

Nitro-glycerine	52	per cent.
Infusorial silica and sand	30	"
Carbon	12	"
NaO NO^5 formerly Ba ONO^5	4	"
Sulphur	2	"

Its advantages, as compared to dynamite, are: 1. Greater sensitiveness to temperature, exploding at 120 deg., while dynamite explodes at 190 deg. 2. Greater sensitiveness to moisture from the presence of the hygroscopic nitrate of soda. 3. The gases from the explosion always contain carbonic oxide from the carbon in the compound. 4. For equal volumes it has the less explosive power.

DUALINE.

Dualine is superior to lithofracteur; its composition is :

Nitro-glycerine	50	per cent.
Fine sawdust	30	"
Nitrate of potassa	20	"

Compared with dynamite, it is: 1. More sensitive to heat and also to mechanical disturbances, especially when frozen, when it may even be exploded by friction. 2. The sawdust in it has little affinity for the nitro-glycerine, and at best will hold 40 to 50 per cent. of nitro-glycerine, and on this account very strong wrappers are needed for the cartridges. 3. Its specific gravity is 1.02, which is 50 per cent. less than that of dynamite ; and as nitro-glycerine has the same explosive power in each, its explosive power is 50 per cent. less than that of dynamite. 4. The gases from explosions, in consequence of the dualine containing an excess of carbon, contain carbonic oxide, and other noxious gases. Lithofracteur and dualine, however, can be exploded when frozen by means of an ordinary fulminating cap, which is not the case with dynamite.

NITRO-GLYCERINE.

Nitro-glycerine is an oily liquid of a sp. gr. of 1.6, having a sweet aromatic taste, colorless when pure, but as manufactured is usually light yellow. If heated up to 100 deg., no change takes place ; heated gradually to 193 deg., it is decomposed, losing its explosive power. When not under pressure it burns quietly. Heating when confined may create a partial decomposition, and an explosion from the pressure thus generated. An electric spark will pass through it without causing explosion unless a series of sparks are passed through it until decomposition is caused and heat generated. Fire alone, ordinarily, will not explode it. Jarring nitro-glycerine, even when at a temperature of 50 deg. C., will not explode it. Explosions occur: 1. When confined and heated to 180 deg. C. 2. If struck so as to create heat and pressure; percussion causes it to explode with difficulty when frozen, which takes place at 8 deg., but striking it when in that state with a sharp hard substance, as a pick, will then easily explode it. Most of the accidents with nitro-glycerine are the results of carelessness. According to Bolley, Kundt, and Pestalozzi, dynamite explodes : (*a*) by a considerable increase of temperature when confined ; (*b*) by the action of intense light when confined, caused by the heat evolved ; (*c*) by a heavy blow when confined, or, when unconfined, between hard substances ; experiments on this subject show that between iron and iron, if the blow is sufficiently heavy, an explosion usually occurs; between iron and stone it is uncertain; and between iron and wood none will take place; (*d*) by electricity, if the action is kept up to decomposition of the explosive; (*e*) by spontaneous decom-

position which was not attained experimentally, in which respect it is much less dangerous than nitro-glycerine.

In Sweden alone, up to the close of 1868, over 300,000 lbs. of nitro-glycerine were used, and the factory at Hamburg manufactured monthly over 30,000 lbs. of dynamite.

The decomposition of nitro-glycerine, as of gun-cotton, under ordinary temperatures is very slow, gradual, and quiet. Fumes mostly nitrous, are given off, the nitro-glycerine turns greenish, then nitrous oxide and carbonic acid form, finally crystals of oxalic acid appear, and some months after the beginning of the decomposition the whole becomes a jelly-like mass of oxalic acid, water, ammonia, etc. The evolution of gas was rapid enough to generate the heat and pressure necessary to explode the compound.

Nitro-glycerine, when taken into the stomach, is poisonous, but not fatal, even in large doses. Caustic, potass, and hydriodic acid are antidotes, but cannot be used for internal application. Those who work in it should wear gloves, and when they leave their work to eat, should wash their hands in a weak solution of caustic potassa, and then in water ; 1 part of nitro-glycerine is soluble in 800 of water, which is then injurious to health for external or internal application. If, in using the substance, a blast is fired improperly, *i. e.*, some of it is fired by the fuse and not by the fulminate, carbonic oxide and nitrous oxide are formed, which are injurious to those who breathe them ; but if the fulminate alone explodes the charge, the resulting gases are principally carbonic acid and oxygen, which do no harm. Good ventilation in mines, etc., where nitro-glycerine is used, should always be kept up. The gases resulting from the explosion of gun-cotton are about the same as those from nitro-glycerine.

Explosive Power.

	Powder.	Nitro-glycerine.	Gun-Cotton.
Mixture of gases in c c. at 0° temperature produced by 1 gramme of the explosive	200	2,000	1,200
Temperature of these gases in degrees Centigrade	3,300	5,200	4,500
Theoretical maximum pressure in atmospheres (1 kilogramme to 1 square centimetre)	4,300	26,000	15,300
Theoretical maximum power per kilogramme of explosion in kilogrammetres	42,000	400,000	200,000

From this it appears that for nitro-glycerine the theoretical maximum pressure is six times, and the theoretical power is ten times that of gunpowder. Piobert says that gun-cotton burns eight times as rapidly as gunpowder, and nitro-glycerine burns still more rapidly. Dynamite, it has been found, explodes downward, and needs but little tamping. The tendency developed toward cleaving and splitting radially around the shot in the direction of the weakest lines of fracture. In compact stone, even with but little tamping, the tendency is to crushing. Strong, slow burning explosives split the stones less, but have less power in compact masses of stone, though under any circumstances, where gunpowder is used, deep tamping is necessary. Ordinary blasting powder is of no value in such stones. Strong explosives diminish the work of boring. In soft loose earth, strong and quick burning explosives are poor, a strong slow burning powder being needed. With such explosives as dynamite, the more consistent the earth the better the results. In blasting with dynamite the shot may be placed perpendicular to the surface, or in the direction of the weakest part, with good results. Hard tamping is unnecessary ; natural cracks, druses, are not detrimental to the effects of dynamite. The holes need not be so deep for dynamite as for gunpowder. If frozen, the dynamite should be carefully thawed out by warm water, or a stronger fulminate should be used. For blasting in water or watery rock, only the fulminate need be protected, unless the cartridges are to remain in water some time, when endosmose might set in through the parchment paper walls of the cartridge, and the nitro-glycerine be entirely replaced by water. The other nitro-glycerine powders are as susceptible to water as gunpowder; moreover, their explosive power is less than that of dynam-

ite, inasmuch as they contain a less percentage of nitro-glycerine. Gun-cotton must always be protected from dampness when it is to be used.

Dynamite saves 30 per cent. and nitroglycerine from 30 to 40 per cent. more than gunpowder, in time, labor, and tools. It is calculated for blasting in moderately hard syenite a saving of 33 per cent. is effected by the use of dynamite; in close grained syenite or pure granite 42 per cent., and in feldspathic or quartzose rock 45 per cent. Experiments show that for equal quantities of nitro-glycerine and powder used, the former loosens five to six times as much rock as gunpowder. Dynamite and nitro-glycerine throw pieces of rock to a less distance than gunpowder, and are therefore safer for blasting near dwellings ; larger pieces of stone are split off by them, which may be more readily used for building stone, etc. In blowing up embankments, nitro-glycerine is weaker than powder, but it is good for countermining in military operations. Dynamite has been suggested for use in felling large lumber, and displacing roots of trees; by its aid also the strongest iron constructions can be burst. As it is unaffected by water, it could effectively be used for torpedoes. Where several shots in a blast have to be connected, tubes filled with dynamite running from one to the other will give a more simultaneous explosion.

Nitro-glycerine, etc., should not be transported or kept with other explosives, as gunpowder, petroleum, spirits, etc. The fulminate for firing the cartridge should also be kept separate. Small quantities are best kept in an underground apartment. Larger quantities should be kept in low buildings of wood, about which earth has been heaped, which should be from 1,000 to 2,000 paces from any dwelling. If the nitro-glycerine powder commences to decompose and give off fumes, water should be poured over it, and it should then be covered with earth. Complete directions for transportation, preservation, and use, should accompany every lot of nitro-glycerine compound sold.

RESUME.

1. The preparation of nitro-glycerine, and the explosive mixtures of which it forms a part, particularly dynamite, is simple, safe, rapid, and gives a uniform product. 2. These preparations can be rendered safer for transportation and keeping than gunpowder. 3. The loss from decomposition is less than the deterioration of gunpowder by pulverization and dampness. 4. For equal weights, dynamite has from two to ten times the strength of gunpowder ; for equal volumes, four to sixteen times. In the use of dynamite, 20 to 40 per cent. of expense and 40 to 70 per cent. of time is saved. For equal weights dynamite removes 5 to 6 times as much rock as powder, for equal volumes 8 to 10 times. 5. In water or rock impregnated with water, 50 per cent. of expense, and 100 per cent. of time is saved by the use of dynamite. 6. The gases resulting from the explosion of dynamite are much less noxious than those from that of gunpowder.

A comparison of dynamite and gun-cotton gives the following results: 1. For equal volumes, gun-cotton is less powerful than dynamite by 30–40 per cent. Gun-cotton costs 20–30 per cent. more than dynamite. 3. Gun-cotton for marine blasting, has all the disadvantages of gunpowder. 4. The gases from the explosion of dynamite are less noxious than those from the explosion of gun-cotton. 5. Gun-cotton is more sensitive to heat and mechanical derangements than dynamite. Dynamite is also easier of preparation.

The disadvantages of dynamite are: 1. The easy separation of nitro-glycerine from the silica by water, in case the cartridges, permeable to water, are left for some time submerged. 2. Becoming hard at a temperature which causes difficulty in working and using it.

The German Iron Trade.—The German rolling mills are generally well provided with orders, as a good deal has to be done to meet the demand for railway *materiél.* The demand for engines and machinery, which had been much depressed, is also reviving.

It has been ascertained from official sources that 1,223 houses were destroyed during the two sieges of Paris, the cost of reconstruction and reparation of which will be 445,000,000 francs ; this is exclusive of the movable property, jewels, and articles of art.

ANIMAL MECHANICS.

From "The Engineer."

Last Tuesday afternoon the Rev. Samuel Houghton, M. D., Dublin, D. C. L., Oxon, F. R. S., gave the first of 3 lectures at the Royal Institution, on "The Principle of Least Action in Nature, illustrated by Animal Mechanics."

Dr. Houghton said that he would give a few examples to show what he meant by "The Principles of Least Action in Nature." If we suppose the earth to be a lazy, intelligent, living animal, swimming round the sun, we only require to know the points A, B, S (Fig. 1), to mathematically calculate its whole orbit, on the as-

FIG. I.

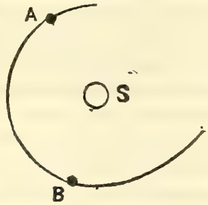
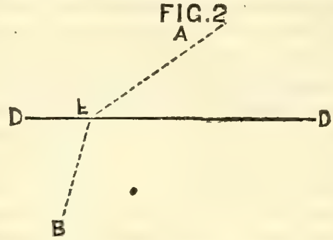


FIG. 2



sumption that it is a living animal swimming round the sun in such a way as to get through its journey with the least trouble to itself. On the same principle his hypothesis was that in every arrangement of joints, muscles, bones, and parts, the arrangement must be such that the muscle will occupy exactly the position it would take if it were a living intelligent animal, which had sought the place where it could do its work with the least trouble to itself. By means of the hypothesis it is possible to calculate the position of the bones, sockets, and muscles, and it is one which he believed would prove to be a valuable key to unlock the secrets of animal mechanics.

He would give another illustration. Let A, F (Fig. 2.), be a ray of light passing through air, and striking the surface, D D, of a block of glass; the ray is refracted by the glass in the direction F B. If the ray be assumed to be a living thing, trying to take the path which will give the least trouble to itself, its path can be predicted mathematically on such an assumption quite as accurately as by the laws of refraction.

He would give a third illustration. One day he watched some oyster women in the Mumbles harbor, near Swansea. They filled their baskets with oysters, and then the ground they had to traverse consisted of two parts. The first part consisted of slippery shingle, and the second of plain common. The line, D D (Fig. 2), would serve to show the division between the shingle and the common, and A the position of the oyster women. They were thus placed in the same position as the ray of light in the preceding illustration, but what surprised him was that they did not walk straight to the common as he would have done, but went off in a slanting direction, and made a "tack." After seeing this he measured the angles made by their path, and by the one he would have taken; then he mathematically determined the relative roughness of the two roads, and found they had chosen the best they could possibly take to save unnecessary waste of power. He did not suppose they had any more consciousness that they were doing so than the planet or the ray of light already mentioned; they were not, however, lazy animals, but good industrious women, doing the maximum of work with the minimum of effort, their path being determined by Him who made them.

As another illustration, he would call attention to the hexagonal cells made by the bee, whereby the largest quantity of cell-space is made with the minimum amount of wax.

Nature, or the intelligence which underlies nature, has to produce a certain amount of muscle to do a certain amount of work, so it is obviously to the interest of the creatures formed by nature to do their work with the least possible quantity of muscle.

Before it is possible to advance one step in the scientific investigation of animal mechanics, it is necessary to ascertain the coefficient of muscular force. In the case of a rope its coefficient would be the number of lbs. weight necessary to break it across. Suppose a rope, 1 in. sq. in cross section, made of muscular fibre, were hanging from the roof of the theatre of the Institution, what weight would it lift from the ground by its contraction? That weight would be its coefficient. It cost him 12 years of hard work to determine this point, and to obtain the following figures for human muscle :

Arm	94.7	lbs. to the sq. in.
Leg	110.4	" " "
Abdomen	107.0	" " "
	104.03	lbs., the real coefficient of muscular force.

Until the foregoing coefficient was obtained he could take no steps in the application of geometry to anatomy. He was obliged to make his experiments with human beings only, because none of the hairy animals with long tails had intelligence enough to aid him by doing what he required of them. As regards men, he had to measure the power of their muscles during life and the size of their muscles after death. In walking across the room a vast number of muscles are brought into play, so the difficulty is to ascertain the power of each particular muscle, and from such movements the inquirer cannot work back to know the force per unit of cross section of each muscle.

By work in hospitals, where some of the patients suffered from diseases in which muscular contractions were a leading feature, he gained some of his data, and in other directions he sought for more. He learned how to work the treadmill so as to get through the task with the least trouble to himself, and he could now do it in a lazy manner as well as the cleverest burglar in London. He also knew the easiest part of the wheel to work at. The key by which he first obtained a clue to these secrets was an ounce of tobacco, which key he found competent to unlock the heart of the surliest burglars. In short, he had been led to think that kindness might do more with criminals than severity, and he found that both English and Irish burglars and thieves were much better people than he expected.

He not only had to determine the power of the muscles of young healthy men during life, but to measure their dimensions after death. Many of his examinations after death were necessarily made upon elderly persons, wasted by long sickness, and this tended to give false results. He, therefore, to get accurate results, had to watch for chances of examining subjects who died suddenly by violent deaths, or who were executed by the hands of the law, but in Ireland he found many impediments to this line of action. In the case of violent deaths by accident, the cause of death was usually so obvious that the coroner could not order an examination of the remains, and the friends of the deceased were usually so anxious to "wake" him, that they would not permit scientific dissection of the body. Then as to those who suffered by the hands of the law, in Ireland murders of a social or private nature incurring the penalty of death are almost unknown, and men are usually only executed for agrarian crimes ; in such cases the criminal has with him the sympathy of such large masses of people that it would be very dangerous for a scientific man to dissect the body of any patriot who has shot his landlord. While beset with these difficulties, a clever, but rather wild, scheme entered his head of taking a farm at Westmeath, refusing to pay his rent, shooting his landlord, and then dissecting the body at his leisure. But he saw that certain inconveniences might attend this plan ; in short, he believed, upon his honor, that public opinion in Ireland would not tolerate the shooting of a landlord in order to obtain the coefficient of muscular force.

However, he had at last succeeded in obtaining the coefficient, and the use which could be made of it he would explain in his next lecture.

Zinc Production of North America.—In 1860, only £15,000 worth of zinc ore, and £2,250 worth of zinc, were produced in the United States ; whereas, up to the end of June, 1870, the State of Missouri alone produced £6,625 worth of zinc ore, and £21,250 worth of zinc, or £10,625 worth more than the whole produce of the United States 10 years previous.

THE ST. CHARLES BRIDGE.

From "Chicago Railway Review."

It has been scarcely five years since iron railway bridges (except suspension) over great rivers were regarded as of doubtful practicability, both in their scientific and commercial aspects. As regards suspension bridges, there have never been wanting scientific croakers to prove that they could not long bear, and business croakers to declare that they would not longer bear their own weight, to say nothing of that of passing loads. Every year the Niagara bridge is bound to fall; but somehow it still vindicates the engineering skill and the practical sense of Roebling. And now every great stream is spanned with beam bridges, permitting vessels to pass under or through them without impediment. The Missouri, Mississippi, Ohio, and Hudson will soon be bridged at every point which the interests of railway transportation demand. The Missouri River has five; two, Kansas City and St. Charles, completed; two, Leavenworth and Omaha, approaching completion; and one, at Glasgow or some neighboring point, to be begun at once and speedily built. Another will be provided for very soon at Atchison, and probably still another at St. Joseph.

The Mississippi is bridged at Rock Island, Clinton, Dubuque, Burlington, Quincy, and St. Paul; and bridges are in progress at Hastings, Winona, Keokuk, and St. Louis. The Ohio is bridged at Louisville, Parkersburg, Bellair, and Steubenville, and will soon be at Cincinnati; and at no distant day bridges will span the river at Cairo, Memphis, and other points. The Hudson is bridged at Albany, and will have a railway high (suspension) bridge at Anthony' Nose, as was described in last week's "Review." Of this score of bridges the average cost will probably exceed $1,000,000 each. That at Kansas City cost $1,200,000; that at St. Charles, $1,800,000; that at Leavenworth will cost about $775,000; and that at St. Louis $5,000,000. These are large sums, swelling to an immense aggregate; but the investments representing them are among the best ever made in railway construction. Simply as investments to the owners they are paying properties; while to the railway and business interests they are beyond price. The want of these now would incalculably set back the progress of the country during the present decade. It would effect a revolution "backward" which would be nearly fatal to commercial enterprise under its present auspicious conditions of certainty, celerity, and economy of transportation.

HISTORY OF THE ENTERPRISE.

The second railway bridge, and the first high bridge, across the Missouri, was completed and opened to business May 29, at St. Charles, as described in our last issue. Talked of long before the rebellion, that event silenced all consideration of the project for 5 years. During this interval, however, great railway bridges had been thrown across navigable streams, without impediment to river commerce. Kansas City was moving in the matter of a R. drawbridge; and necessity, which is the mother of business enterprise as well as of invention, imperatively demanded that a decision to build a bridge of some sort here be no longer postponed. In 1866, the R. Co. offered a premium of $1,000 for an acceptable plan, which was awarded to Mr. Charles Kellogg, of the Detroit Bridge Works, for a Bollman Truss—a wooden draw, with stone piers. The utter impracticability of this scheme became apparent as soon as the character of the river at the point decided on (from the present ferry landing to the St. Charles depot) began to be understood. In April, 1868, Mr. C. Shaler Smith was invited as Engineer-in-Chief of the Bridge Co., to make a thorough survey of the river at this and adjacent points, and prepare plans for a high iron bridge at the most feasible crossing. Mr. Smith had from 1857 to 1861 been engaged on several iron bridges, as an assistant; from the latter date to that of his summons to this work, he had been building bridges as Chief Engineer, or destroying them as a Confederate engineer officer (Captain) almost continuously. Associated with his brother, he had then built more bridges of over 300 ft. span than any other engineer in this country. Familiarizing himself—as eloquently described by Mr. Eads in his address quoted in our last

issue—thoroughly with the laws governing the river at the proposed point, and mastering all the topographical and dynamical conditions, he finally submitted drawings and estimates of a structure to cost about $1,000,000. The plan being adopted, operations were begun in August, 1868. The first stone was laid in Sept., 1868 ; the last in April, 1871. The R. Co. had issued $500,000 of bridge bonds ; but the change in plans rendering this sum inadequate, a Bridge Co. was organized on a capital basis of $1,000,000. Of this the R. Co. holds $350,000, and private citizens $650,000. The company is organized as follows :

President—Wm. M. McPherson.
Secretary—Edward J. Mitchell.
Chief Engineer—C. Shaler Smith.
Directors—James B. Eads, Gerard B. Allen, John G. Copelin, J. R. Lionberger, and Wm. M. McPherson.

The bridge will be operated by the N. M. R. Co. as lessees. The rent is at present $150,000 per annum. The operating of the bridge is equivalent (in time) to a shortening of the road 17 miles. Had Capt. Smith's proposition been adopted to carry the iron trestle on a level to the adjacent bluff, and to tunnel the latter (under very favorable conditions) near its summit, there would also have been an *actual* shortening of the road by several miles, besides avoiding ugly grades and curves. The cost of the bridge has amounted to nearly double the original estimate—amounting to $1,750,000, in addition to which there should be still expended $65,000 to perfect the protecting works, and finish everything up entirely. The items of expenditure are :

Foundation	$554,000
Masonry	310,000
Protection	28,000
Approaches	125,000
Superstructure	474,000
Outfit	203,000
Engineering	15,000

The details hereafter given will show how impossible it must have been to make even an approximate estimate of the cost of the finished structure. No scientific prescience, while estimating quite correctly the "constant" of materials in the bridge proper, could tabulate the uncertain "variables" of ways and means which have swollen immensely the aggregate of actual cost. There is an engineering economy of the books ; but the economy of *practical* engineering is quite another affair. For example, the original estimate of cost of pier—$65,000—though large in the light of all previous experience, proved far too small, in a stream having 40 ft. rise and 43 ft. scour. Pier 5 alone cost no less than $101,000. There has been an expense, apart from direct work done, of $7,000 a month merely to "keep things moving," where every known condition was so hard, and so many obstacles still greater were unforeseen. The flood of July, 1869—destroying the protections of Pier 4, and the caisson of Pier 3—threw work back fully 9 months. We present the following details of the work, furnished by the Chief Engineer :

Length of bridge and iron trestle work, feet.	6,570½
Length of bridge, feet	2,178
Earth excavation, yards	354,000
Concrete, yards	3,900
Piling (lineal), feet	103,000
Lumber and timber, feet	3,686,000
Wrought iron, pounds	4,454,000
Cast iron	2,769,000
Iron in caissons, pounds	517,000
Masonry in bridge proper, yards	12,000
Masonry in shore approaches, yards	4,000
Riprap in pen foundations, "	35,000
Distance above high water of 1844, feet	51
" " low water, " "	90
" " ordinary water, "	80
Area of premises on St. Charles shore, acres	16
Average number of men employed	400
Largest No. steam engines employed at one time	22
Pile drivers in actual use	7

Mr. Smith has had the following assistants :

Principal Assistant, in charge of masonry and foundations—Joseph L. Sherrard.

Assistant in charge of false work and works outside of protection—Capt. C. C. Wrenshall.

In charge of office and draughting—John A. Kay.

Field Assistant—Julius Moulton.

BRIDGES IN GENERAL USE.

Mr. Thos. C. Clarke, Chief Engineer of the C., B. & Q. R. Co., in his very valuable treatise on the iron R. bridge built at Quincy, under his supervision, refers the various combinations of open-work girders to three classes :

I. Bowstring, and other parabolic girders.

II. Suspension girders, like the Bollman and Fink, in which long tension rods transfer the weight directly to the abutments.

III. Beam trusses, of which those in common use reduce to three classes :

1. The triangular, in which equally inclined braces, acting alternately as struts and ties, transfer the weight to the piers.

2. The Howe, transferring the weight by diagonal struts and vertical ties.

3. Quadrangular girders, vertical struts and diagonal ties ; the former exposed to compression, and the latter to tensile strains only, the parts in compression being reduced to a minimum.

This last variety of Class III. is exemplified in various bridges in general use, chiefly those built upon the "Pratt," "Whipple," "Murphy," "Linville," "Lowthorp," and "Post" designs, in all of which the same principle is applied under different proportions and sections of parts and forms of connection. In lattice-girders the triangular becomes quadrangular (adopted in the Quincy bridge) simply by the addition of the vertical post. The lattice-girder is composed of a multitude of small parts (wrought iron) connected with rivets. The strains are so subdivided, that the breaking of a single part is not fatal to the whole.

In the open work, or skeleton-girder, the parts, not all of wrought iron, necessarily) are few, and are connected with pins. The advantages of the pin-connection will be hereafter stated. In the Quincy bridge (although the engineer declares, theoretically, in favor of wrought iron parts exclusively), he was led, for good special reasons, to introduce cast iron also ; and the different spans, 17 in number, were built on different plans—quadrangular for the fixed spans of the main bridge, and Bollman for the bay-bridge, both fixed spans and draw. There was here an eclecticism which probably should characterize the design of any bridge structure consisting of many spans, built under different conditions. In designing the St. Charles bridge, the Chief Engineer, Mr. C. Shaler Smith, pursued the same enlightened course. In doing this, he exemplified the spirit in which he wrote (in 1866) the very remarkable monograph—"Comparative Analysis of the Fink, Murphy, Bollman and Triangular Trusses." [Baltimore : 1870.] The introduction contains a paragraph in which is stated a practical maxim that would seem to have been uppermost in the engineer's mind during the entire 3 years of the prosecution of his *magnum opus* at St. Charles :

"The books and journals abound in theories of trusses expressed in algebraic symbols unintellibible to nine-tenths of their readers ; and, however ingenious and even sound the theories reached through their complex equation may be, they are so entirely disregarded by the designers and builders of the structures to which they refer, that they are in effect only an agreeable exercise of the faculties of the learned men who propound them. * * * In truth, the conditions of the several questions which present themselves in planning a truss are so many, and so founded on what the engineer who experimentally tests the bridge can alone obtain a full knowledge of by noticing the effect of passing trains at various speeds, that it is not to be wondered at that the skilful algebraist, in framing his equations in his study from only a general idea of the movements which take place, should omit some quantity which ought properly to enter into them."

As the result of his analysis, Mr. Smith regards the Fink truss as embodying the triangular principle in a form securing to the parts more freedom of elongation and contraction, independently of each other. The feet of the upright post (supported by the apex of the triangle) are free to move ; and, under depression, maintain their position normal to the curve of the chord, making the distance from the foot of the post to the points of suspension always relatively the same, and leaving the trusses, whatever their position, in equally good adjustability as before the deflection. When this principle is applied to the overgrade, the fact is the same ; in this case, the flooring is suspended from the feet of the posts by compensating links, permitting the same free motion as before. Mr. Smith, at the close of the treatise referred to, summarizes his conclusions, by enumerating the four classes, analyzed in their order of value for different purposes.

We condense : Compensation under load and charge of temperature—Fink, Triangular, Bollman (for short spans), Murphy.

Facility of restoration to proper form, after load is removed—Bollman, Fink, Triangular, Murphy.

Weight of load, great in proportion to

truss—Suspension best, and Fink variety preferable.

Undergrade of any span ;

Overgrade of more than 100 ft. span—Triangular the best.

General adaptability, action under load, compression under temperature—Fink superior.

Distribution of material, proportionate strength to weight, and first cost—Triangular the best.

Adjustability—Bollman superior ; as also for short overgrade span.

Mr. Smith claims for the Fink truss, for spans of 400 ft. or more, the maximum economy of material. His reasoning is this : In the Fink overgrade, only the chord, main system and pier towers are increased in the usual proportion to length of span common to all the smaller systems ; while the post can be cut off at that length in which the requisite strength is combined with the minimum of material, a suspension rod being dropped from its foot down to the floorway. In 400 ft. span, $12\frac{1}{2}$ ft. panel, only the main and quarter posts are of the full weight of the truss ; the rest are cut off at the point necessary to bring the tension bars of the system supporting them to the angle of 45 deg. with the vertical lines of the posts. This secures a material saving in iron in long spans, as is illustrated in the following tabular exhibit, which we compile :

Bridges.	Length of span.	Weight per lineal foot.
Fink....................	400 feet.	2,825 lbs.
Dirschau Bridge, Prussia..	387 "	4,644 "
Cologne	313 "	4,750 "
Steubenville..............	320 "	3,561 "

On a 375-ft. span, the Fink and Triangular coincide in cost.*

The Fink bridge is simply a double Warren. The principle of the Kansas City bridge is identical, except that it has an additional end panel and a counter-rod (tie) running down in every direction. The St. Charles bridge is stated by Mr. Smith to be the first exemplification, on a large scale, of the Pin Joint, pure and simple. The post fastens to a pin, both at the top and bottom, and the entire span consists simply of a multitude of parts connected by free-acting joints.* The aim has also been to concentrate materials to the utmost in large masses; to duplicate parts only when unavoidable; no post is made in two pieces—additional stiffness, with less weight, being secured by combining two posts in one. There is a complete double system of lateral bracing for both posts and chords. The structure is, in a word, a continuous one in principle; and so completely is it one in fact, that whatever calculation—whether of safety or danger—applies to any portion applies to the whole. Instead of being "no stronger than its weakest part," every part is as strong as the whole. At the end of two days of passing and repassing, with passenger cars, coupled engines, and long freight trains, we were, it is true, unable to entirely get rid of the physical nervousness which attended the climbing for the first time of the "gossamer-like" (appropriately so characterized by Col. Eads) iron trestle leading to the airy spans over the stream; but with every scientific demonstration—and Mr. Smith favored us with such very patiently, more than once—that no section could move except as the whole moved, and that the whole could not be moved by any weight that could be placed upon it, or by any ordinary natural force that could be impelled against it; and especially with every actual experience of the absolute stability not merely, but the literal "unshakeableness" of both trestle and bridge span beneath the heaviest train—one learns to less and less take counsel of his

* Of course, in the above, we are simply quoting Mr. Smith. For the valuable treatise, we are indebted to Mr. Benjamin H. Latrobe, of Baltimore, from whom we received it several months ago. We cannot refrain from adding here an extract from a brief review of Mr. Smith's monograph, from the pen of Mr. Latrobe, in which fitting recognition is made of its dispassionateness and equitableness :

"He does not make himself the champion of any one model, but fairly sets forth the properties of each. * * * He does not disparage any, but temperately points out what he regards as its deficiencies, admitting that bridges can be made strong and safe even upon the plans he considers most open to objection, and bringing their respective claims to the test of economy in construction and maintenance."

* Mr. Clarke, in his treatise on the Quincy Bridge (p. 18), gives the following summary of the advantages of the open-work girder with pin and screw connections :

"No deduction being necessary for rivet holes, nearly the full sectional area of the iron can be utilized, and a bridge carrying much less dead weight can be constructed on this than on any other plan.

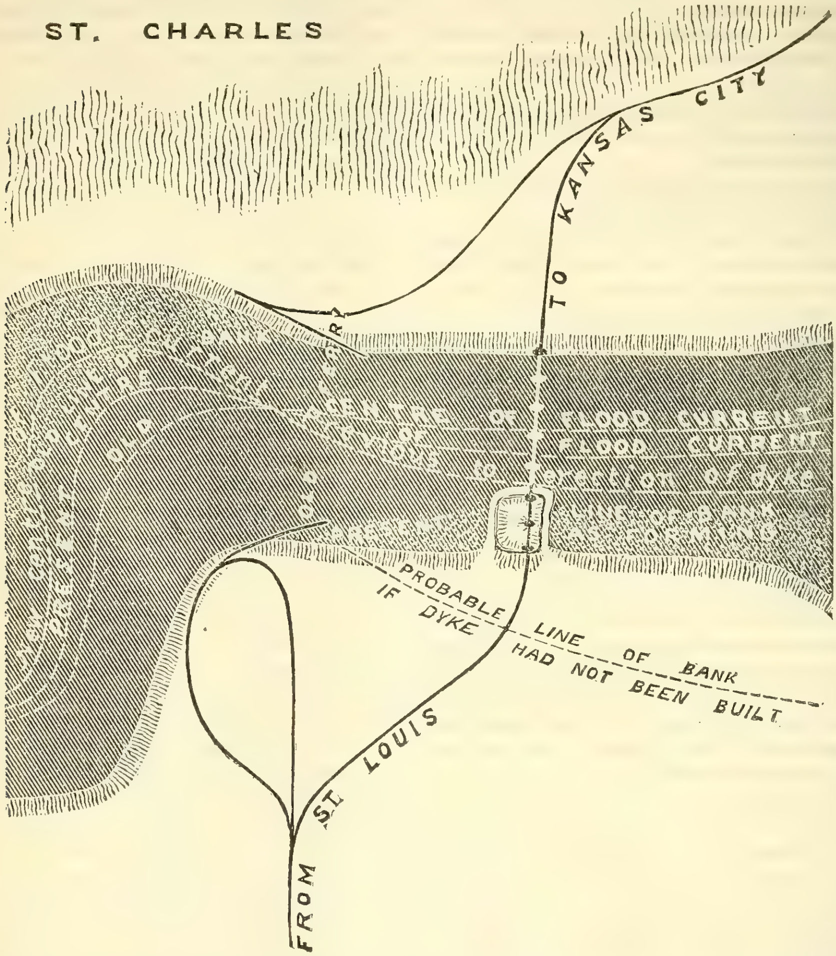
"From the fewer number of parts, better workmanship can be obtained, with less exposure to rust.

"A bridge with pin connections can be put together in one-fourth of the time required to build a riveted lattice-girder.

"Pin-connections were adopted, therefore, in the Quincy bridge, on the ground of durability, economy, and celerity of construction."

fears, and reposes very much the same unstudied faith in the stability of the structure that he does in the "uniformity of nature."

MAP SHOWING LOCATION OF ST. CHARLES BRIDGE.



In describing the plan of St. Charles bridge and approaches, we naturally begin at the south end, at which we approch it from St. Louis. A reference to the map exhibits the line of the road before reaching the valley, as parallel with that of the bridge. The distance between the two parallels is 3,000 ft. This circumstance—and not, as might naturally be supposed, the necessity of reaching the bridge-level—renders necessary the curves on the approaches. The centre of the bridge is $53\frac{1}{2}$ ft. above the road grade. The length of the southern approach is about 1 mile. In this distance there is a rise of 52 ft.—1 in 100, the maximum grade of the road. On the north side the bridge-level is reached with a similar grade in about half a mile, the ascent being $25\frac{1}{2}$ ft. On the south side there are two 4-deg. curves—one on embankment, one on trestle; on the north side there is one 4-deg. curve, partly on embankment, partly on trestle.

Leaving the road-grade, going north, the approach to the bridge consists first of 1,700 ft. of embankment, rising to a height of 28 ft. At this point the iron trestle is reached, 2,880 ft. long. Passing to the bridge, piers 8, 7, and 6, support 2 Fink deck spans of 406 ft. each. This brings us to the first channel span, also

Fink deck, 306 ft. resting, on piers 6 and 5. Piers 4, 3, and 2 are the deep water piers. On these—piers 5 to 2—rest 3 spans (Trellis girder), from 321½ to 318 ft. long. Resting on piers 2 and 1 (at north shore) is a Fink deck span 304 ft. Leaving the bridge we pass down the grade on 1,700 ft. of iron trestle; thence down embankment, 28 ft. high, grade continues 900 ft. to the road level.

The height of the bridge (clear) is 50 ft. above high water, and 90½ ft. above low water. The 3 deep water spans give a clear water way of 900 ft. This broad channel is secured to the navigation interest, as long as "wood grows (to build boats with) and water runs" (to float on); and in this channel, though "cribbed, cabined, confined," the tawny monster may yet wander at his own fierce will, sporting tumultuously in vast beds of ever-shifting sands. This bridge should be noted as the only one yet built which gives to navigation more than 2 channel spans. The Louisville bridge has 2; as have the B & Ohio R. bridges recently built at Parkersburg and Bellair.

RIVER BOTTOM.

The current at this point has a velocity of 9½ miles per hour.

Immediately below the water, sand is encountered, varying in depth from 4 to 38 ft.; below (after sometimes passing heavy drift masses) there is a layer of boulders about 21 ft. thick, interspersed with sand strata of from 6 to 18-in. thickness. The boulders are of every variety of rock found west to the summit of the Rocky Mountains. This deposit lies permanently on the bed-rock, the depth of which below low water, at the different piers, numbering from the north side, is pier No. 1, 11 ft.; No. 3, 18 ft.; No. 4, 49 ft.; No. 5, 68 ft.; No. 6, 72 ft.; No. 7, 76 ft.; No. 8, 71 ft.

SUBSTRUCTURE.

Columns and Piers.—The columns of the iron trestle approaches, rest on concrete abutments from 18 to 22 ft. high (appearing but a few feet above the surface of the ground), which are surrounded by dykes, 28 ft. broad on top, which is 3 ft. above high-water mark. The river can never, it is seen, flow over the sand bottom over which the approach is made; but is kept between the channel piers, securing under all circumstances of high water or low a straight channel. The piers supporting the bridge are 9½ ft. thick under the lower coping, and 12 ft. across the coping.

The piers were all located by direct measurement. For this purpose fine steel piano-wire was used, having a weight at each end, and dynameter, spanning readily 600 ft. Intermediate piers were located from two opposite breakwaters, the wire having the same strain.

SINKING THE PIERS.

We take the piers in the order in which they are numbered, from the north.

Pier 1.—This was sunk without difficulty, in three weeks, by means of the ordinary short pile coffer-dam.

Pier 2.—A caisson dam was used in 9 ft. of water; and an excavation, 6 ft. further, was made in the bed rock. The work occupied but 2½ weeks.

Pier 3.—A caisson dam was used, packed outside with concrete. An attempt being made to pump out the water, the bottom blew up, on account of resting on a ledge of friable limestone. Excavation was then carried on under water by divers, through this rotten stone to the depth of 7 ft.; and the space was afterwards walled up with masonry laid under water, with concrete backing. When the caisson was again ready to be pumped out, the great flood of July, 1869, came. The drift islands (one 300x400 ft. in extent) packed one upon another, crushing it to atoms. But the foundations remained intact, and when the water went down, a caisson boat was floated to the spot on which the pier was built, gradually sinking to the foundation. Work was prosecuted on this pier fully one year.

Pier 4.—A bottomless caisson, having double walls, with stone packed between, was sunk to the bed of the rock, by dredging inside the caisson. This was exceedingly difficult, on account of the mass of drift and boulders encountered. The method was adopted of feeding boulders and sand to the dredges by means of very heavy jets. It became necessary to use a 1½ in. jet from a No. 8 Cameron pump, 12 in. diam., 2½ ft. stroke, 18 in. cylinder; the pressure averaging from 80 to 110 lbs. When the boulders proper were encountered, the bucket was taken out of every other dredge, and a claw of 2x4 in. iron

attached in its place, to bring up the stone. The divers were also employed the whole time. A 12 ft. cement foundation was then built under water. To this the pier was lowered through the caisson (as through a tube) by means of 44 screws, $2\frac{1}{4}$ diam., keeping the top of the pier above water. This caisson was an immense structure, its dimensions being 54 ft. deep, 68 long, and 24 wide. Work on the pier extended over a period of 7 months.

Pier 5.—This pier was sunk by pneumatic pressure through 68 ft. of sand and boulders. The difficulties encountered were equally serious with those above described, and wholly different therefrom. Work was begun in 2 ft. of water, the river bottom at that time being simply a sand-bar. Simultaneously with the work of lowering the crib, there began a dissipation of the sand-bar forming the bed; and the recession kept on until the crib had to be lowered 30 ft. before the sand was reached. The caisson was built on a pontoon at the shore. A flat boat was brought and placed athwart the current, having 2 16-in. pumps, with jets running from it directly across the bar. Divers beneath the water directed the jets, driving the sand into the river-current, thus working an opening across the bar. To appreciate the magnitude of these operations, the reader should understand that a sand-bar 90 ft. long was thus excavated *under water*, in a swift current, to a depth of 4 ft. in 16 hours. The excavation being accomplished, the pontoon bearing the caisson was floated to the spot, and the caisson supported by screws. The work of sinking progressed favorably to a depth of 31 ft. from the surface, 16 ft. of which was through the sand-bar. At this stage came the same flood of 1869, above spoken of. It drove a sub-current of water diagonally, scouring under the caisson, and causing it to pitch forward continually. The excavating work of the current under one end of the caisson had to be supplemented with that of men burrowing under the structure at the other, removing the sand from beneath the downstream end. It was possible to work but 24 men at once, but this number was kept continuously at work day and night. A half hour's cessation of work with this force would have placed the caisson at the mercy of the current, and it would have toppled over and been swept away. Do the best they could, it was moved from its designated place 3 ft. backward, and 2 ft. sideways. The work of sinking the caisson occupied 49 working days, day and night. The bottom once reached, the rock was cleared off, and there was no other trouble.

Pier 6.—A bottomless caisson was sunk 30 ft., and along with it a protecting ring of riprap, 88 ft. in diam. The same process was employed in

Piers 7 and 8, each of the three being under construction about 6 months. Work was prosecuted at one time on 4 piers. Seven pile-drivers were operated. The piles (sycamore wood, exclusively) were 2 ft. diam., and from 58 to 65 ft. long. It required 24 hours to drive a pile in the foundation piers, though commonly from 8 to 10 a day were driven. A few piles required 5,000 blows, a large number 3,200; some only from 600 to 800. On account of the yielding of the wood to long-continued hammering, the blows had to be greatly varied in force.

In the construction of such a work it should not be forgotten that the expenditure of money, time, skill, and invention on preliminary engineering ways and means, forms a large and often discouraging item. Not only is there outlay of these in the survey and location of the bridge, in the negotiation of judicious contracts for manufactured iron, and in the getting together of the "raw materials" of stone and earth,—but the providing of the requisite mechanical aids is a very weighty matter. In many respects the demands of the work may be fully anticipated — as respects appliances, for instance, for getting the various parts and materials into place; but emergencies, of which those noted in the above account of the building of the piers, are a specimen, are constantly arising where the engineer is put "on his muscle"—physical, mental, and *moral*, and the men on their *morale* for days and weeks together, night and day, incessantly. For example, in order to rear the massive yet delicate structure to its dizzy height, "false work" of the most substantial character must be built above the stream, and anchored secure amid its rushing, fickle waters, deep in its shifting bed. In a word, you must first build *a* bridge in order to build *the* bridge. And not only must the false

work support the true, but it must at the earliest possible moment be in greater or less measure held in place thereby. In one instance here, the foundations of the false work were swept away by the ice-flood, but the entire body of the temporary superstructure was held securely suspended above by the span only just now reared upon it. Each of these eight piers required a preliminary outlay of from $12,000 to $15,000, largely on ice breakers and other temporary means of protection, before it could be built. Mr. O. Chanute, Chief Engineer of the Kansas City bridge, the first built over the Missouri, has calculated that the friction of Missouri River sand per square foot on surface of caisson and other similar works is 10 42-100 lbs. × depth in feet. In this connection the disturbing force of the current is to be considered. This depends on the velocity of the water and the weight of bodies with which it comes in contact. The disturbing power increases according to the sixth power of the velocity. If a 3-mile current moves a 2-lb. stone, a 6-mile current will move a 64-lb. stone. This shows how it is that this river, whose velocity is prodigiously increased with every rise above its average surface, scours holes of such vast size and depth in a few hours. Here, then, are conditions of "wear and tear" always present and operative, and liable to increase beyond calculation.

Then, as regards the protection against the ice, it is hardly possible to construct any merely temporary works fitted to resist the immense force of the ice-floods. Yet the engineer must get absolute security. Mr. Smith solved this exacting problem by fighting ice with ice. He constructed his ice-piers in such manner as to encourage accumulations of ice, the pieces congealing to a solid and more immovable mass with each addition.

Again, the dangers from ice masses past, the warm season with its floods brought equal peril from earth masses—the flood often hurling along a floating island several hundred feet across, large enough to carry forest trees *in situ*, mass impinging on mass, and the united weight of the whole "mobilized" against the frail framework, or the half-finished foundation of the pier.

Among all the Protean shapes assumed by this dis- (or un-) embodied force, this malign river-god, as our ancestors would have fancied, that of the fickle water and sand currents are among the most resistless, yet evasive.

Here, for example, is this "breast of scour," as it is termed—simply an immense subaqueous peripatetic sand-bank, dragging its by no means "slow length along,"—now with the direct current of the stream ; now across it from shore to shore ; constant only in its inconstancy; evoking the interest, energies, and skill of the engineer to provide against it in one place and form, only to demand still more in another. The engineer points out to us the end of a solitary pile a few hundred feet above the bridge, inclined in the direction of the current. It is the single remnant of a goodly company that were to play their protecting part in the work going on. Driven down 26 ft., at the end of one day, the next morning saw them all "scoured out" except this one. Often, too, when the river is really "falling" rapidly, there being a marked diminution in the volume of water, the channel deepens, by reason of the more rapid displacement of the sand. There are, in fact, here *two* rivers, the water-river and a sand-river now beneath, now mingling with it,—each separate, yet both interdependent; whose laws are past finding out, except, in their results; acting now independently, now jointly. 'Tis a word and a blow, and the blow first.

And as regards regular appliances—what with the boats, the dredges, the derricks, the pile-drivers, the pumps (both for water and sand, the divers in armor, the water-jets, and the whole multitude of special tools—the evil sufficient therefor, which each day brings forth,—you only wonder when you see them that the outlay on them has not been twice as great.

Among the most curious of such mechanical aids is this elephantine "double-motion" derrick,—rather, it should be said, a "universal" lifter and carrier. Stretching out its giant arm, it seems some huge, amorphous human slave, picking up in sullen silence a massive timber or stone at one extremity of the barge, and depositing it in another without shock or noise.

A NEW CHANNEL.

Perhaps the most striking feat of this

whole series of labors of Hercules stretching through 3 long, busy years, was that of changing, straightening and securely establishing a channel for the river. A reference to the map will show the general features of this—the respective lines of the old, the changing, and the present channels; and the location of the dyke, at the south end of the bridge proper, by means of which the change to the present channel was effected. The channel has been on the north side. Little by little, and at length with great rapidity, the current cut into the shore—a distance of 1,435 ft., about $\frac{1}{4}$ of a mile, in a single month. This, of course, as the habit of the river is, produced a reflex current, which swept across to the south side, and threatened the instant destruction of works already in progress, and the decisive thwarting of the entire plans of the engineer. Accordingly, crying out in the pure instinct of self-preservation—"Thus far shalt thou come, and no farther;" and "here shall thy proud waves be stayed,"—Science began building a wall in the face of this transverse current. The effort to run out a breakwater directly in face of the current was, however, fruitless. There was the "resistless force," but not the "immovable body." Accordingly, the effort was made to run out light pile-work to break the force of the current, and to push the dyke simultaneously. In this the engineer succeeded. The dyke itself, too, was built on a system of "indirection"—by running out rock-jetties, and filling the space between them with sand. The difficulty of this work will be appreciated when it is stated that the channel here, which was previously only 4 ft. in depth, had been suddenly deepened by "scour" to 18 ft. near the south shore, and to 35 ft. at the outer edge of the present dyke. The dyke was at length completed, inclosing an area of 400x720 ft. It is composed, as hinted, of sand with coating of stone, to which it is regarded by the engineer as necessary still to add 5,000 yds. of riprap. It was built at an outlay of $47,000. It has thrown the channel (making a straight current in a sharp bend) permanently between the deep-water piers. Its effect extends a distance equal—up stream to $1\frac{1}{4}$ its own length, and down stream to $2\frac{5}{10}$ times the length of the dyke. Inside the dyke, the workmen had to work (on piers 1, 2, and 3) in from 6 to 18 ft. of water; but this is being gradually filled in with earth.

STRENGTH OF THE BRIDGE.

The maximum compression to which the stone of the piers in any place is subjected is 1,000 lbs. per sq. in.; and it has been tested to 11,500 lbs. The uniform pressure on foundation is 70 lbs. per sq. in. The apparatus used was a hydraulic, of Mr. Smith's device. As respects the superstructure, the whole was put together on the spot, after being tested there. The preliminary test was to 20,000 lbs. per sq. in.; the maximum strain that can be imposed will be 12,000 lbs. The limit of elasticity was fixed at 1-1350th; if under the test the iron passed beyond that, the piece was rejected, even though it returned to its original form. The cast iron, manufactured expressly, is a special mixture composed of one-third scrap and the balance equal parts of Iron Mountain, Lake Superior and Scotia.

The Test.—The test at the opening was made by

Capt. Jas. B. Eads, Ch. Eng. Ill. & St. L. Br. Co.

Chas. Pfeiffer, Assistant Eng. Ill. & St. L. Br. Co.

Thos. McKissock, Ch. Eng. and Supt. Mo. Pac. R.

Geo. Morrison, Asst. Eng. Kansas City Bridge.

Maj. H. H. Benyard, U. S. A. Eng. Corps.

Maj. A. Stickney, U. S. A. Eng. Corps.

Gen. Wm. F. Reynolds, U. S. Army Eng. Corps.

Col. J. N. Macomb, U. S. A. Eng. Corps.

S. T. Emerson, Ch. Eng. N. Mo. R.

J. B. Lodge, Ex. Eng. "

Major O. B. Gunn, Ch. Eng. M., K. & T. R.

L. B. Boomer, Pres. Am. Bridge Co.

J. B. Moulton, Ch. Eng. and Supt. Om. & S. W. R.

The level tests were made by Julius Moulton, M. Robinson, A. F. Schmioedt, Mr. Emerson, F. H. Pfeiffer, and S. H. Young.

	1st Quarter.	Centre.	3d Quarter.
1st Fink span ..	2⅞ inches.	3⅝ inches.	2¾ inches.
1st Trellis span..	1⅛ "	3 "	2⅛ "
2d Trellis span..	2½ "	3⅛ "	2⅛ "

When three-fourths of the 2d Trellis span was loaded, the end of the load deflected it 2 in.; when one-half was loaded deflection was $1\frac{5}{8}$ in.; when one-fourth loaded, $\frac{3}{4}$ in.

The test to 10,000 lbs. per sq. in. was but one-sixth the whole strength of the iron. The entire weight of the Trellis span is 780,000 lbs. The engineer states that this is lighter, by 300,000 lbs., than any other iron span of 300 ft., except that of the arched bridge at Coblentz, which is, of course, destitute of the lower chord. It may be interesting to state the maximum weight of the posts—along with the chords the heaviest portions of the bridge. The long Fink posts weighs 11,500 lbs.; the Trellis post, 11,900.

NON-CONDUCTING STEAM CYLINDERS.

From "The Engineer."

The specific heat of cast iron, the material of which steam-engine cylinders are all but invariably made, is about one-ninth that of water—precisely, it is .1138, water being unity. A unit of heat is that amount of caloric which will raise 1 lb. of water from 39.1 deg. through 1 deg. Fahr. A pound of steam at atmospheric pressure contains 1146.6 such units; as the pressure increases so does the number of units, but the increase is very inconsiderable. We shall be near enough to the truth, if we assume that steam of an average pressure, such as is common in engines expanding fairly, contains about 1,150 units per lb. Now the same quantity of heat, measured in units, that would raise 1 lb. of water through 1 deg., will raise 9 lbs. of cast iron through 1 deg. It must be understood that it will not raise 1 lb. of cast iron through 9 deg. unless the *intensity* of the heat, which is a totally different thing from its *quantity*, is measurable as 9 deg. by a thermometer. We make this statement for the benefit of our young readers, who we know by experience are apt to confound quantity with intensity. It will be seen from the foregoing that cast iron is about one-ninth part as efficient, weight for weight, in condensing steam as is water, and this truth realized we are in a position to understand what takes place in the cylinder of a steam engine. Temperature in such a cylinder may, and under ordinary circumstances will, vary through a range of at least 100 deg. The amount of range will fluctuate with that of the temperature of the incoming steam, and that of the vapor in the condenser or that of the atmosphere; but we shall be sufficiently near the truth if we assume the variation to be 100 deg. Deducting 212 deg. from 1,150 deg., we have 938 deg. left as what is known as the latent heat of the steam. Now, if we were dealing with water instead of cast iron, by dividing 938 deg. by 100 deg., the temperature through which each pound of water would have to be raised, we should obtain as a quotient 9.38 lbs.; that is to say 9.38 lbs. of water would be sufficient to condense 1 lb. of steam to water having a temperature of 212 deg.; but iron is only one-ninth as efficient as water, therefore nine times as much would be required. Putting all this into a definite proposition, we have the statement that every 84.42 lbs. of cast iron raised through a temperature of 100 deg. condenses a pound of steam. A thoroughly efficient engine, working expansively, will give out 1 indicated horse power to every 20 lbs. of steam passing through the cylinder per hour. If, however, this steam has to raise 85 lbs. or thereabouts of cast iron through 100 deg. in each hour, we lose 5 per cent. If double the quantity of iron is operated on, or if the time be halved, we lose 10 per cent., and so on. From this we deduce the axiom that the temperature of the cylinder should not be permitted to vary, but should always be as great as the greatest temperature of the steam at any time in the course of a stroke.

It will be seen that however carefully a cylinder may be clothed, one great source of loss of heat cannot be prevented. The lagging precludes the transmission of heat through the walls of the cylinder to the atmosphere, but it cannot affect in any way the phenomena going on within the the cylinder. When steam first enters, it heats up the metal to a certain point. The inner surface will be the hottest and the

outer surface will be coolest, and the time taken to bring the two surfaces to the same temperature will vary, other things being equal, with the rate of conduction proper to the metal and its thickness. But it is evident that in any case a considerable weight of metal must be heated and cooled per stroke, and each 85 lbs. of metal so heated and cooled through 100 deg. per hour represents a loss of one-twentieth part of 1-horse power. If the material of the cylinder were perfectly pervious to heat, but had no capacity for storing it up, no harm would be done, because we could, consistently with the demands of practice, use a perfect non-conductor as a lagging, which would prevent the radiation of heat, while possessing a very small capacity for caloric itself. But cast iron stores up heat at one portion of each stroke and gives it out in another portion of the stroke. We may, to use a very rough but forcible illustration, regard the metal as a sponge, which absorbs heat in its pores during the period when the steam in the cylinder is doing work, and from which the heat so absorbed is squeezed out into the condenser when the exhaust port opens. The amount of heat thus wasted is enormous, especially in slow running engines, which allow time for the transmission of heat through a considerable thickness of the metal of the cylinder. The cylinders of some oscillating marine engines weigh as much as 28 tons each, or 62,720 lbs. Not less than 737 lbs. of steam must be condensed to raise one of these masses of metal through 100 deg. It is fortunate that the transmission of heat through the iron is so slow that not more than a ton or so of the metal really varies through that range of temperature after the engine has been blown through and fairly warmed up; were it it otherwise, the steam engine could not exist.

In order to avoid or reduce condensation in steam cylinders, we must construct them either of a material which will conduct heat so slowly that only a small portion of its total weight will alter in temperature; or of a material having so low a specific heat that any moderate quantity of caloric will suffice to raise it through the required range of temperature; or, finally, of a material which will combine both these characteristics. Wood would satisfy the first condition very fairly, but it is obviously inapplicable to the required purpose. It is practically impossible to dispense with the use of metal in steam-engine cylinders; but it does not appear to be essential that we should confine ourselves to the use of heavy cast-iron cylinders. For small engines it would be possible to use cylinders of very thin steel carefully lagged. Such cylinders could not absorb much heat; they would be too light. For larger engines a different arrangement would be necessary. An examination of any good table of specific heats will show that lead stands very low in the scale as compared with cast iron. Whereas the specific heat of the latter is, as we have stated, .1138, that of the former is but .0293. The specific heat of iron is to water as 1 to 9; the specific heat of lead is to water as approximately 1 to 34. It would require nearly 300 lbs. of lead to do as much mischief in a cylinder as 85 lbs. of cast iron. Nor is this all. We have shown that much of the influence for evil of the material of which a cylinder consists depends on the rate at which heat is transmitted through its substance. In this respect also lead excels cast iron. The conductivity of lead is but three-fourths that of cast iron. In the entire range of the metals none appears to be so available for our purpose as lead. In order to use it, the working surface should be composed of a thin steel cylinder placed in an outer case of cast iron, the space between to be filled with lead run in and compressed by hydraulic pressure. It does not appear to us, however, that the list of materials available for our purpose is exhausted by the metals. By adopting the principle of using a very thin metallic cylinder, and backing up and strengthening it by other substances, much may be effected to economize steam. Wool can now be compressed into so hard a mass that blocks of it can be turned in a lathe. Who in the face of such a fact will assert that we are compelled to adhere to the use of cast iron—almost the worst material of which a steam cylinder can be made?

MICHIGAN turned out 1,750,000,000 ft. of white pine last year.

THE gold crop of Montana for the year 1870 was $44,000,000.

ON SOME FORMS OF THE GALVANIC BATTERY.

By S. B. SHARPLES, S. B.

From the "American Journal of Science and Arts."

While making some experiments as to the best method of determining nitrous acid, Dr. Gibbs had his attention called to the fact that nitrous acid is instantly oxidized by an acid solution of potassic bichromate to nitric acid.

This result he communicated to me in the early part of 1870, saying, at the same time, that he thought it might be advantageous to use a mixture of nitric and sulphuric acids and potassic bichromate, as the absorbing liquid in the porous cell of the Bunsen battery. The chromic acid would prevent any evolution of nitrous acid by oxidizing it as soon as formed to nitric acid. The nitric acid being the active fluid in the combination would prevent the polarization which is continually taking place in the ordinary bichromate battery, and would be constantly renewed.

Having occasion to use a battery a few days after, I tried the mixture with such satisfactory results that it seemed desirable that the subject should be more fully investigated. The electro-motive force and internal resistance of the battery were therefore determined.

The apparatus used was one of Poggendorff's rheostats, which was furnished with 16 metres of German silver wire, the resistance of this being but little affected by changes of temperature. By means of clamps, any number of centimetres of wire could be introduced into the circuit. When the needle of the galvanometer was deflected to 40 or 50 deg. a change of one centimetre in the length of the resistance could be readily seen. The galvanometer was an ordinary one, in which the coil was replaced by a broad, thick, copper band, passing once around and close to the needle, which was suspended by a filament of silk, and so adjusted that it was at the zero of the scale when it came to rest in the meridian.

In order to determine the internal resistance I made use of two elements of the same construction, which could be thrown into the circuit either singly or side by side. I found, when all my connections were bright, that there was no appreciable difference between the two elements, that is, either element when connected with the galvanometer, would deflect it the same number of degrees.

The zincs were about 4 in. high and $2\frac{1}{2}$ in. internal diameter, with a slit in one side. The porous cups filled the internal space almost entirely. The carbons used were those manufactured by Chester, of New York, for ordinary medical batteries, and had a section of about 1 sq. in. The exciting liquid was a mixture of sulphuric acid with 9 times its volume of water; this was found to be without action on the zincs when the battery was not running. The zincs were kept well amalgamated.

The electro-motive force was determined by Wheatstone's method, as follows:—One of the cells was thrown into the circuit; the rheostat was then adjusted until the needle stood at 40 deg.; the resistance was then decreased until the needle rose to 50 deg.; the length of wire removed was noted. The second cell was then placed by the side of the first and the resistance increased until the needle again stood at 50 deg., and the added length of wire noted. While both cells were connected the needle was brought again to 40 deg.; by removing part of the resistance, this length was also noted; it should correspond exactly to the first length. One of the cells was then removed, and the resistance again adjusted; the wire removed should exactly equal the second length noted above. The second cell was now substituted for the first, and if the needle still remained at a constant point the measure was considered satisfactory. If there was any discrepancy in the measurements, or if the needle stood at a different point with one cell from what it did with the other, the connections were all examined and the measurements repeated. It was rarely found necessary to make more than one trial.

The formulæ used were those given by Wheatstone (loc. cit.), as follows:—For electro-motive force $\frac{E}{E'} = \frac{l}{l'}$ in which E = the electro-motive force of a standard battery, and e the length of wire necessary to reduce the needle of the galvan-

ometer from one given point to another given point. E' = the electro-motive force of the battery to be determined, and l' the length of wire which was required to be removed to change the needle from one of the given points to the other.

For the internal resistance of the battery, $R = 2l$, in which formula R = the internal resistance, and l = the length of wire which must be added when a second cell is placed by the first to bring the needle to the same point where it stood when only one cell was in circuit. After making one series of measurements, the needle was brought to 40 deg., and allowed to remain at that point for 12 hours if the battery remained constant for that length of time ; the measurements were then repeated and compared with those of a Bunsen cell made under the same circumstances.

The first measurements, made in March, 1870, were merely to determine the electro-motive force. In the rest of the experiments, made in December, 1870, and January, 1871, the internal resistances were also determined.

1*st Experiment.*—For purposes of comparison, a Daniell's cell was fitted up, using the same zinc and porous cup, and the same exciting liquid, but substituting for the carbon a hollow cylinder of copper open at one side, and using a saturated solution of cupric sulphate as the absorbing liquid. The mean of six comparisons of this with a Bunsen's cell gave 169 for the electro-motive force of the latter, Daniell's being 100. Latimer Clark gives the number 175.

Ex. No. 2.—The porous cell was filled with a saturated solution of potassic bichromate in a mixture of equal parts of nitric and sulphuric acids, diluted with 4 times their volume of water. This gives a constant battery working without giving off acid fumes until the exciting liquid was exhausted. Its electro-motive force was the same as that of the ordinary Bunsen cell.

Ex. No. 3.—The porous cell was filled with coarse fragments of potassic bichromate, and then saturated with nitric acid. The electro-motive force was the same as in the last experiment, but the battery was not quite so constant, and there was a great waste of bichromate, there being much more than was requisite to saturate the nitric acid.

Ex. No. 4.—The cell was filled as in the last experiment, only the liquid used was a mixture of equal parts nitric and sulphuric acids. The electro-motive force was the same, but trouble was experienced from the formation of crystals of chromic alum which encrusted the carbons and porous cells and stopped the working of the battery.

Ex. No. 5.—The absorbing liquid was a saturated solution of potassic bichromate in hydrochloric acid. The electro-motive force of this battery rapidly declined; starting with the same force as Bunsen's, in the course of $2\frac{1}{2}$ hours it ran down to two-thirds of that force; its internal resistance at the start was 1.7, that of Bunsen's, at the end of $2\frac{1}{2}$ hours it was 3.6. It gave off chlorine during the whole time it was in action.

Ex. No. 6.—The absorbing liquid was a saturated solution of potassic bichromate in nitric acid. It gave the same electro-motive power as the ordinary Bunsen cell, but the internal resistance was about 2.3 as much. The battery was sensibly constant for 12 hours.

Ex. No. 7.—Ex. No. 1 was repeated under slightly different circumstances. The saturated solution of bichromate used in the last experiment was mixed with one-third its own volume of strong sulphuric acid, and enough water added to take up the precipitated chromic acid. This formed the most satisfactory battery tried; it was perfectly constant during 12 hours. The internal resistance was only about $1\frac{1}{2}$ times that of an ordinary Bunsen's cell of the same construction, and not the slightest odor could be perceived in the room. The electro-motive force was the same as that of the Bunsen cell.

Ex. No. 8.—Having seen in the American " Chemist " a notice of a new battery by Prof. Bunsen, mentioned in an address by Prof. Roscoe, before the Chemical Section of the British Association for the Advancement of Science, I made a trial of it. This battery consisted of two metals, platinum and zinc, with a single fluid, namely, a solution of chromic acid in dilute sulphuric acid; I tried it in a small cell in which equal surfaces zinc and carbon were opposed to each other. The electro-motive force was twice that of a Daniell's cell, or 1.2 that of a Bunsen's; but it was not very steady, and the chromic acid acted strongly on the zinc.

Ex. No. 9.—Dr. Gibbs suggested to me to try a solution of chromic acid in nitric acid in the porous cell, using sulphuric acid in contact with the zinc. The electromotive force was the same as in the last experiment, and the internal resistance was the same as in the Bunsen cell. The battery was perfectly constant. Two cells very slowly decomposed pure water and gave vivid flashes of light when the connections were made.

Ex No. 10 was undertaken to determine the effect of replacing the bichromate by manganic oxide; the porous cell was filled around the carbon with manganic oxide; nitric acid was then poured on it until it was completely saturated. This gave very poor results; the electro-motive force was about 1.43 times that of a Daniell's cell. The battery was not very steady, and after running some time began to give off fumes of nitrous acid.

Ex. No. 11.—Joule gives an experiment with a battery in which platinum in nitric acid is used as the negative, and zinc in caustic potassa as the positive electrode, and gives the electro-motive power as equal to 2.41 Daniell's. I repeated the experiment, using a solution containing $\frac{1}{5}$ of its weight of potassic hydrate in the outer cell, and a saturated solution of chromic in nitric acid in the inner cell. I found the electro-motive force at first about 2.35 that of Daniell's cell, the internal resistance being that of a Bunsen's cell. It was rather unsteady at first, and then began to gradually decline. No odor was perceptible.

Several experiments were tried, with the hope of obtaining a single fluid battery, with the following results:

Ex. No. 12.—A strong solution of caustic potassa was made, saturated with ferricyanide of potassium, and used in the cell employed in experiment No. 8. This gave a feeble current, and the carbon was rapidly polarized.

Ex. No. 13.—As solutions of sulphurous acid and acid sulphites dissolve zinc without evolution of hydrogen, forming hyposulphites, it was thought that these might be used as the exciting liquids. They gave a very feeble current, and the carbon was soon polarized. The sulphite of zinc formed also adhered to the zinc and prevented further action.

Ex. No. 14.—Iodide of potassium saturated with iodine was tried; this also gave a feeble current, and the carbon soon became polarized.

Ex. No. 15.—A cell of the Maynooth battery was fitted up, and a saturated solution of potassic bichromate in nitric acid used as the absorbing liquid; the battery was not very constant, and the iron was soon attacked; no fumes, however were given off. The electro-motive power was about .55 of a Daniell's cell.

The result of these experiments seem to show that the battery used in experiment No. 7 is the best for ordinary use, since it costs but little, if any, more than the Bunsen battery charged with nitric acid alone, and is entirely free from fumes until exhausted. If the following directions are observed in preparing the fluid, it cannot fail, I think, to give satisfaction.

To prepare the exciting liquid, sulphuric acid of 1.84 sp. gr. is mixed with 9 times its volume of water, and allowed to stand until the precipitated lead is all settled. The clear acid is then decanted and is fit for use. This plan of preparing the acid has been in use in this laboratory for some years, and gives very good results, local action being almost entirely prevented by the removal of the lead.

To prepare the absorbing fluid, ordinary commercial nitric acid is saturated with potassic bichromate; this should be done in a warm room, as it takes up much more when warm than when cold. The solution thus prepared is mixed with $\frac{1}{3}$ of its volume of sulphuric acid and enough water added to redissolve the chromic acid precipitated.

Two objects are gained by adding the sulphuric acid. The mixture is less expensive than if pure nitric acid is used, and the internal resistance is decreased. If the internal and external cells are properly proportioned, this battery will run until the exciting fluid is exhausted, without giving off any fumes of nitrous acid. If crude chromic acid could be obtained at a sufficiently low rate, No. 9 would be a very powerful and convenient battery for many purposes.

My thanks are due to Dr. Walcott Gibbs for many valuable suggestions made during the progress of this investigation and for the use of the apparatus employed.

New Haven has a Dead Stroke Power Hammer Company.

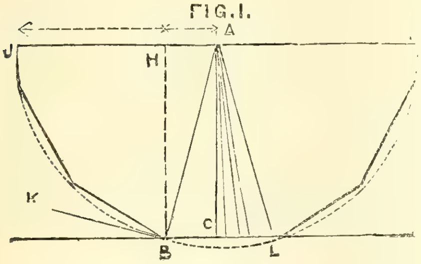
WHY THE BITE OF A ROAD DRIVING WHEEL IS INCREASED BY THE ADDITION OF AN ELASTIC TIRE.

By LEONARD J. TODD.

From "The Engineer."

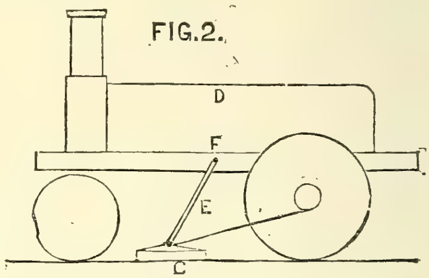
I see, from the remarks of some of your correspondents, that the reason why an elastic tire on a driving wheel increases the adhesion is not clearly understood. In a circular wheel the power necessary to cause the wheel to slip with a driving strain is the weight $\times$ the coefficient of friction; and if the wheel be skidded, the power necessary to sledge it along is the same. If an elastic wheel be skidded, the power necessary to sledge it is as before, the weight $\times$ the coefficient of friction; but the power necessary to cause it to slip with a driving strain is much greater, being the weight $\times$ the coefficient of friction + a second quantity, which depends on the amount of flat; it is this second quantity, which appears to have been hitherto overlooked, to which I would now direct attention.

FIG. I.



Let Fig. 1 represent a rigid wheel with flat sides, or with spokes only, the rim being removed. Now, if the centre A be fixed from rising, the wheel evidently cannot slip, owing to A B being greater than A C; were the centre not fixed the wheel can only slip either by its turning at the point B, as a fulcrum, or by the axle rising so as to allow the line A B to become vertical under it; in either case the strain required to do this (that is, driving strain to turn the wheel) is greater than if the wheel were circular, for there must, firstly, be a certain amount of power applied at J, great enough to raise the total weight on the wheel while turning at B; and after it is balanced at this latter point there must, secondly, be an additional amount applied to cause B to slip backwards. The first quantity varies according to the weight on the wheel and the length of the flat side, and the second according to the weight and the friction. If this wheel be skidded the power required to sledge while resting on its flat side will only be this latter quantity.

FIG. 2.



The reason why the bite of such a flat-sided wheel is increased is also shown in Fig. 2. Let D represent a locomotive, E a rod, vibrating at a fixed point F, and G a large flat shoe, and let a rope extend from the shoe to a small winding drum on the extremity of the main axle, the driving wheels to be disconnected. If, then, the bearing surface of the shoe be great enough to prevent it from sinking it cannot slip backwards, for the rod F G being rigid, then would the whole engine have also to move backwards; and if F were fixed at the centre of gravity, and the strain on the rope sufficiently great, the engine would be lifted and carried forward a certain distance, and if there were a succession of such rods and an endless rope attached, we should have a very powerful hauling engine.

There is another point that may be noticed in this arrangement, and especially in the wheel with rigid spokes, viz., that the driving strain of the spoke A B must necessarily act at right angles to it in the direction K B, forming a considerable angle with the road, so that a lesser coefficient of friction will keep the point B from slipping backwards than what would be required if the spoke were in the position A C, and the driving strain con-

sequently applied parallel to the road in the line B C.

Neither of these arrangements, however, would answer in practice, as they would first hold and then slip, while the jolting would shake the engine to pieces. The practical development of the principle of obtaining an endless fulcrum at B, on which the wheel can continually be turning, while yet preserving a smooth motion for the engine, consists in a flexible driving wheel, which was first successfully carried out in Thomson's well-known engine by placing a thick band of rubber on each wheel.

In further considering the action of an elastic wheel we may suppose it to contain an indefinite number of spring spokes as between C and L, as being convenient for consideration. It has been shown that a wheel with a rigid spoke A B cannot slip without raising the centre A; but as in the elastic wheel the spoke A B contains a spring which must be weak enough to yield with the weight on the axle, it follows that if the driving strain be great enough the point B will slip backwards, compressing the spring, the axle A remaining stationary; and as the power required to compress the spring is less than that required to raise the axle, it follows that the elastic wheel will slip more easily than the theoretical rigid one with a fixed line A B.

Having now determined the manner in which the adhesion of an elastic driving wheel is increased, and to what cause it is due, it will be well to determine in what measure this takes place with any given amount of flat. First take a circular wheel carrying a load of 3 tons, then the power to sledge it along the road, and also the driving strain to slip it, both = the weight 3 tons $\times$ the coefficient of friction, say 700 lbs. = 2,100 lbs. Then in the rigid wheel with flat sides the power to *sledge* it = the weight 3 tons $\times$ coefficient 700 lbs. = 2,100 lbs., as before, but the driving strain necessary to slip it = weight 3 tons $\times$ coefficient 700 lbs. + a sufficient strain applied at the circumference to raise the weight of the wheel when turning at the point B; then as with the "angle of adhesion" shown the lines A H J are three to one, the strain required will be $\frac{1}{3}$ of 3 tons = 2,240 lbs. at the circumference, or 2,350 lbs. at the point C, and the result becomes:

Weight........................ } Friction...................... }	= 2,100 lbs.
Angle of adhesion..............	= 2,350 lbs.
	4,450 lbs.

for each wheel, or 8,900 lbs. for the two drivers. Thus by giving an angle of adhesion of about 14 deg. the bite is more than doubled. This refers to a theoretical wheel in which the amount of flat is constant, and the line A B rigid as the wheel rolls. In an elastic wheel, however, this is not the case, and as the tire necessarily forms springs for the engine, the angle of adhesion continually varies and the available bite will be rather less than that given. However, this result very nearly agrees with practice, for in Thomson's 8-horse power engine, with a working pressure of 125 lbs., and allowing $\frac{8}{10}$ in the cylinders, the strain, at the point $C = \frac{28 \times 100 \times 10 \times 17.5}{57} = 8{,}590$ lbs., or very slightly less than the adhesion was calculated at; and when it is considered how a very slight variation of the angle of adhesion or the coefficient of friction, or a few pounds of cylinder pressure, would affect either side of the equation, the agreement becomes more marked. Or, again, allow the engine to weigh 7 tons, then friction at $\frac{1}{30}$ and road resistance at $\frac{1}{30}$ = 1,032 lbs. for the engine alone, leaving 7,418 lbs., or 3 tons 6 cwt., of useful tractive force that the engine can exert on a level at a maximum effort, which is also realized in practice, the wheels when thus burdened but slightly slipping on dry macadam.

It may be remarked that according to the foregoing calculation of the adhesion, supposing the friction between the wheel and the road were absolutely *nil*, that the engine should still haul a considerable load. It has already been shown that the point B in the wheel with flat sides cannot slip backwards without raising the centre A, and the strain that must be applied in the direction B C. To do this will be, say, 1,100 lbs., or 2,200 lbs. for the two wheels, but as the road friction is *nil*, the resistance to motion along it will be the same, and consequently on level ground there is hardly any limit to the load which the engine might take. It does not follow, however, that an elastic wheel would hold nearly so well as this, for, as has been shown, the line A B can become compressed and pass under the centre; but as it

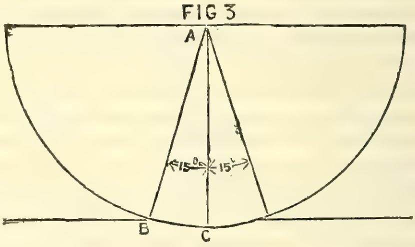
must require *some* amount of strain to do this, and as there is not any resistance to the motion of the engine, it could still propel itself although the road friction be *nil.* And it is certain that on the smoothest sheet of ice, if level, that a road steamer with iron shoes could easily run about, having both wheels in gear, but it is doubtful if it could pull much load; however, by allowing bare rubber to rest on the ice a higher coefficient is obtained, and the engine will then take a moderate load, this being, however, greatly owing to the fact that the rolling resistance to the train on such a road becomes extremely small. It need hardly be mentioned that a circular wheel under similar circumstances would be utterly useless.

We thus see that a wheel in which the line A B is rigid will, under all circumstances, hold better than one in which it is flexible. Of course, we cannot make a wheel which while being rigid shall yet also be flexible, but the line A B might probably be made much stiffer than is at present in use. For instance, suppose the imaginary spoke A B to carry 3,360 lbs., and when thus loaded to yield $1\frac{1}{2}$ in., and also that there shall not be any initial strain on it (as is the case with a rubber tire), then the power that will be necessary to compress it $\frac{1}{4}$ in. will be 560 lbs. only. If, however, the spring could be so adjusted as to have an initial strain on it of, say, 2,240 lbs., and yet yield $1\frac{1}{2}$ in. with 3,360 lbs., the strain that would be necessary to compress it $\frac{1}{4}$ in. would then be 2,420 lbs., or more than 4 times that of the previous case, and the bite would consequently be much increased, and yet the amount of flat would evidently be the same in each case.

It will thus be seen that the "bite" of an elastic wheel depends on 3 things: first, on the position of the point B, determined by the angle of adhesion; second, on the amount of stiffness in the line A B; and third, on the amount of road friction. We have no control over the last, but by judiciously proportioning the two first of these, as much bite can be obtained as is practically required.

It may be well here to refer to what seems to be the popular reason for the bite of a driving wheel being increased by an elastic tire, viz., that the increased surface gives increased friction, which is entirely opposed to the law that friction varies according to the pressure and not to the extent of surface. To get over this difficulty it has been declared that this law is true of smooth surfaces but not rough ones, in which the particles interlock; but such parties should first inform us how to make surfaces so "smooth" as to prevent the particles from interlocking, and to what cause, except this, friction between any surfaces is due. But to take the case of two surfaces having artificial teeth like a rasp, if the teeth are made slightly hooked, so as to remain in contact, it is possible that several tons would not slide them laterally; such so-called "friction," however, is clearly a misnomer for shearing strain, which is necessary to sever the teeth. It is hardly necessary to pursue this theory further, as it will not

FIG 3



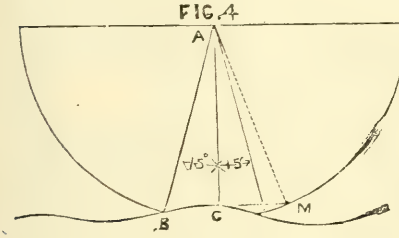
bear the slightest investigation; for if it were correct, then a circular wheel which had sunk a certain distance, as in Fig 3, should have a bite equal to an elastic wheel, as the surfaces are equal. And, again, suppose we took two road steamers of equal weight and disconnected the wheels of one and skidded them, it should then be quite impossible for the other to draw it, for the measure of the strain necessary to sledge the first would, according to this theory, precisely equal the driving strain that was necessary to slip the wheels of the second engine; but it can be proved that No. 2 engine would easily walk off with No. 1, thus proving that a quantity other than that due to friction enters into the calculation of the driving strain required to slip the wheels.

In reference to steam ploughing by direct traction, it has been asked what new thing have we acquired in this year, 1871, which would lead us to expect better success than in 1861? The answer is, that we can now make a driving wheel which shall bite without spikes or paddles in the rims, which we could not before.

Merely increasing the bearing surface will not do this, for if it would, why pay £300 for elastic wheels? We could easily get a greater amount of surface by making thin plate rollers the entire width of the engine, which would then pass over softer ground than any road steamer, but on such land it would be utterly useless as a hauling machine. However, we now seem to have the elements of success before us, which consist, first, in a very light engine carried on sufficiently wide wheels, the two drivers of which must also possess a very considerable angle of adhesion. It does not appear that the weight of the engine is yet nearly so light as it might be. The tractive force which has been developed is amply sufficient, but the adhesion angle might be increased, as it cannot be too great, and if the total weight were much reduced the present width of wheels would seem sufficient.

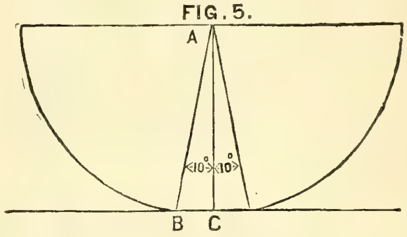
It may here be remarked, in reference to those elastic wheels which have a thick band of rubber the entire width of the wheels, that increasing the breadth of the wheel directly lessens the bite. Suppose a rubber tire 12 in. wide to give an adhesion angle of 15 deg; if, then, the tire be made 24 in. wide, although the surface is increased the angle becomes much less, and the bite is sensibly lessened. This, of course, would not be the case if the 12 in. tire could be divided into two of 6 in. each, placed at either side of the wheel, with the shoes stretching between them; for then, while doubling the bearing surface, the adhesion angle would remain constant, which clearly ought to be the case.

FIG. 4



On reference te the diagrams it will be seen that the bite is increased when A B exceeds A C, and the greater this difference the greater the hold. In Fig. 3 there is increased bearing surface, but as the 2 lines are equal there is not any extra resistance to the wheel turning. In Fig. 4 there is a great difference, and the bite consequently becomes great; by drawing a horizontal line from C to M we see to what adhesion angle it corresponds. In Fig. 5 there is the same amount of yield as in Fig. 1, but in consequence of its tire

FIG. 5.



not being so perfectly flexible as that of Fig. 1, the corner at B becomes rounded, and the angle falls in to 10 deg., the bite being lessened in the same proportion. An apt illustration of this latter case was afforded by a certain one of Thomson's wheels, in which each separate shoe (instead of being jointed to its neighbor by a link, as in the usual practice) was turned up at the ends, the whole set being then strung on two $\frac{3}{4}$ in. rods; which, however, made the chain so stiff, that the corner B became greatly rounded, with the result stated above. So it further becomes evident that the amount of yield does not necessarily bear any connection with an increased bite, for it is very easy to make an elastic wheel which shall answer the purpose of bearing springs and yet which shall not in the slightest degree increase the adhesion.

In making an engine to run on hard roads the principal thing in the driving wheels is to make the adhesion angle as great as possible. If the elastic tire consist of a band of rubber, this would be most advantageously made rather thick and as narrow as was practically safe, for then the angle is greatest. If an elastic wheel rest on hard ground the line B C L will be straight, but if on soft ground the point C will not be in a line with B L, but considerably below, and consequently the difference between A B and A C will be lessened; so it follows that for working on soft ground the wheel should be much softer than for hard roads, so that, in spite of the point C occupying a position below B L, the effective adhesion angle may become the same in either case.

A knowledge of these general principles will be of great use in enabling us to design a direct-action ploughing engine. The first part of the problem consists in making a light engine with the requisite tractive force, having wheels sufficiently wide to carry it; and the second in so correctly proportioning flexible driving wheels as to work up the power developed. The second of these certainly assists the first, but still it by no means follows that by merely increasing bearing surface we can ever attain to the bite required for the second.

In the foregoing consideration of elastic wheels account has not been taken of a certain amount of power which is lost through the medium of the elastic tire, as this does not affect the matter in hand, which was to determine to what cause the increased bite of such wheels was due. It may, however, be remarked that this loss is known to be extremely small.

A few words in conclusion may be said regarding the use of an elastic tire at the leading wheel of a road steamer. If such a wheel have bare rubber running on the road, it will take hold of any slight irregularities and increase the steering power by preventing side slipping; if, however, it has shoes on, it is no more capable of resisting side strain than a circular wheel, and on a hard road the tire is absolutely useless, except to perform the part of bearing springs. On soft land it may be said in some small degree to keep the wheel from sinking, but the load at the leading wheel is not so much as one half that on a driver, and suppose we make it the same width as the latter it will then sink but very slightly; and on hard road, of course, this point is not of any consequence, and on soft ground it would even be an advantage to have the leading wheel to slightly sink, as then the engine steers much more certainly; so that, on the whole, it seems hardly expedient to lay out £50 on an elastic steering wheel, a rigid wheel in this case being practically sufficient.

RUSSIAN RAILWAYS.

From "The Mechanics' Magazine.

The capital of every European State, save one, will be found to be the point to which the railways of the country converge, and the single capital which is an exception to the rule is St. Petersburg. The peculiarity of its geographical position and the character of the region in which it stands are the causes of the exception. Moscow and Kief are in fact centres of the Russian railway system.

The madness of railway speculation in Russia has been pretty severely censured within and without the borders of the Empire; but the madness is checked in no degree. The shoulders of the Government are loaded with a weight of responsibility for the recklessness with which it has granted concession after concession to men of straw, who, armed with the magic tokens of a guarantee from the minister, have hawked their schemes over Europe for sale. Thus have works ill-conceived, and still more improperly executed, been left to dupes to manage, and thus has a fictitious soil been created whereon to sow the seeds of ruin for the days which are in store. To the spirit of competition pervading the share market there seems to come no satiety; and this may be accepted as an instance: At the closing of the subscription for the 12,000 shares of the Kineshma-Ivanovo Railway, a line of minor importance just conceded, the number of shares subscribed was 3,504,669; and on the day following the appearance of the Dvigatel Company, with a capital of only 500,000 roubles, the sum subscribed for the undertaking reached 64,000,000 of roubles, and the shares, all paid up, are now at a premium of from 45 to 50 per cent.

In 1836, which was the 11th year of the reign of the late Emperor Nicholas, Count Bobrinski, long since dead, received a special favor, in the form of permission to construct a railway of about 18 miles in length, from St. Petersburg to Tsarskoe-Selo, the favorite abode of the Russian Court during the months of the summer and autumn. The Imperial sanction, obtained by a trusty and eccentric courtier, marked the origin of railways in Russia; and the Tsarskoe-Selo line, although regarded more as the gratification of the

whim of an old and a faithful servant than as a continuation of the triumph of Brunel, was opened in 1838, and did not only turn out a remunerative concern at once, but has continued to prosper to this hour.

From 1838 to 1845, however, not a single mile of railway was laid within the sacred precincts of the Russian dominions. It was not until 1842 that the Emperor was induced to lend his countenance to the first grand railway undertaking for the union of the modern and ancient capitals of his country. That undertaking was the line from St. Petersburg to Moscow. In nine years this line, over 400 miles in length, was finished at the enormous cost to the Government of £31,666 per verst—a measure which is just $\frac{2}{3}$ of a mile.

The experience gained by the reverses of the Crimean War has not been thrown away on Russian statesmen, who will scarcely permit themselves to stumble in future by shutting their eyes to the strategical work of railways.

The opening in 1862 of the line which connects St. Petersburg with Warsaw, fortunately showed how the interests of the Empire, so far as its integrity went, were identified with the reticulation of the railways, because during the insurrection of the Poles in 1863, the Imperial Government had the power of pouring troops in such continuous masses into Poland that every attempt at resistance was soon rendered impotent and hopeless.

In a country like Russia, where private enterprise is yet undeveloped, having been hitherto jealously and carefully discouraged, the policy of a State guarantee to railway undertakings cannot be regarded as unsound; but the payments to which the Government of Russia is liable under the head of guarantees of railways might greatly embarrass the Treasury at the moment of a financial or other crisis. According to the figures obtained from an examination of the accounts of the credit establishments of the Empire, the yearly liability incurred by the Government on account of the guarantees to railway companies for interest and sinking funds on their shares and obligations, amounted on the 1st of January, 1869, to very nearly £4,000,000. In spite of that formidable sum, the benefits accruing to Russia by giving a guarantee to her railways are most conspicuous in one respect at least. At the time when the credit of the Government was first of all pledged to a resolution of guaranteeing railway enterprises, Russia had long been recognized as a constant and large borrower in the money-markets of Western Europe. But when the fact appeared that she was entering on a new career by supporting these extensive engagements intended for the objects of commerce, her attitude as a borrower received a thoroughly novel interpretation; and her status, not only among capitalists and financiers, but in the estimation of the public, was greatly improved.

For the circulation of money in Russia now-a-days is not what it used to be. Sums do not take months to travel from one corner of the empire to the other. The paper currency has swollen to the respectable and significant amount of more than £100,000,000. Departing from their legitimate path, the banks of St. Petersburg have also assisted in fanning the flame of over-speculation by making advances on railway stock at prices beyond which the value of the railways themselves will warrant. Seeking eventually to stay, the Government has ventured to ease the impetuous rush of the tide, and has enacted that sales on term shall be void in the presence of the law; but the enactment, instead of saving the silly, has only become a boon to the knaves. It lends an incentive to the speculative temper so rampant, by assuring it of impunity. The defaulter cannot be punished.

The Russian railways have been costly; for £100,000,000 have been, or are being, spent on the 7,000 miles of lines already built or being built. But this £100,000,000 may, it is true, be accounted as trifling when the £480,000,000 swallowed up by our English lines are placed by its side. Yet the costliness of the Russian lines is unpardonable when we consider that the blunders of a first experiment did not attach to Russia, but that there was the experience of England to guide and to warn her, and that the scarcity and value of land in England were not to be placed in the scales with the abundance and cheapness of her own.

To the unwary the financial horizon of Russia, being unclouded, promises fine weather for the future ; but to the judgment of those who are not to be deceived by the ever-ascending rate of all sorts of security, the prediction of the rapid rise

of a storm is not a fanciful tale. Twice within one week the Imperial Bank has had the courage to raise its discount 2 per cent. Insane speculation still continues, however, and the Russian people are devising no safeguards against the crash which must sooner or later greet their ears.

CONDENSATION IN STEAM CYLINDERS.

From "Engineering."

The Patent Office records of this and other countries afford abundant evidence of the energy with which a certain class of schemers have devoted themselves to the task of supplying wants which had no existence except in their own heated imaginations, or in the imaginations of persons who, like them, happened to be imperfectly acquainted with the principles of the machine or apparatus which these uncalled-for inventions are intended to improve. Schemers of the class to which we are now referring—and a large class it is—require no such incentives to invention as are required to actuate more ordinary mortals. Very frequently they create imaginary wants for themselves, while at all times they are especially ready to grasp at the slightest hint of an important want existing—no matter from whom the hint may originate—and they immediately set to work to devise means for filling it without troubling themselves to ascertain whether the hint has any foundation in fact or not. To such schemers a most enticing problem has lately been held out by a contemporary of ours, and we do not doubt that some dozens of inventors are hard at work upon it at the present time. Our contemporary has discovered—and has announced his discovery—that the man who can produce a steam cylinder which "will neither absorb nor give out caloric," will "effect the most important improvement in the steam engine that has been made since James Watt invented the separate condenser." Here, then, is a grand field of inquiry opened to inventors, and one in which, as we have said, there are no doubt many laborers. Now we are ready to admit that if such a cylinder as that of which our contemporary speaks *could* be produced, a certain amount of good might result, although not by any means so much as he appears to imagine; but a substance which "will neither absorb nor give out caloric" is at present unknown in nature, and the problem, therefore, requires for its solution the "invention" of a substance differing in its physical properties from any at present known, and capable in addition of being employed in the construction of steam cylinders.

But it may be asked, whether, even if such a substance as that just referred to is not likely to be forthcoming, it may not be possible to so modify the construction of steam cylinders, as to cause them to approximate to what has been termed a condition of "thermal neutrality"? and this question brings us to the chief object of the present article. For one inventor who will search for a material suitable for cylinder construction, and yet perfectly impervious to heat, a score probably will endeavor to turn to account ordinary materials to produce a cylinder which they deem will possess an approach to the desired property. Our contemporary has himself acted in this way, and he gravely proposes to his readers the employment of cylinders composed of a thin steel lining, packed around with lead (that metal having a lower specific heat than cast iron), or with compressed wool or other substances. It is the fallacy involved in the advocacy of such schemes as these that we propose to expose, and in order to do this it may be advisable that we should, even at the risk of repeating well-known facts, recapitulate briefly the circumstances under which internal condensation in steam cylinders takes place.

Condensation in steam cylinders, then, is due to three principal causes, namely: first, to the loss of heat from the cylinder by radiation, etc.; second, to the conversion of heat into work which takes place during the expansion of the steam; and, third, to the cooling of the inner surfaces of the cylinder caused by the evaporation from these surfaces, which goes on to a greater or less extent during the periods of expansion and exhaust. To the first and second of these causes we need only

refer incidentally, as they do not concern the matter specially under consideration, the real question to be dealt with being to ascertain to what extent the condensation due to the last mentioned cause can be reduced by the adoption of such methods of construction as our contemporary proposes. This question we propose to discuss.

When steam enters an unjacketed cylinder, it comes into contact with surfaces at a lower temperature than itself, and a certain amount of condensation takes place to supply the heat requisite for raising the temperature of those surfaces. In the first instance the steam thus condensed is replaced by a fresh supply from the boiler ; but after the point of cut-off is passed, and fresh cool surfaces are exposed to the steam, this condensation causes a loss of pressure in the cylinder. As the pressure falls during expansion, however, re-evaporation commences from the more highly heated surfaces, and soon this re-evaporation exceeds in amount the condensation effected by the fresh surfaces exposed by the motion of the piston, and the curve traced by the indicator then, instead of lying inside the theoretical curve, rises above it, the pressure actually existing in the cylinder at the point of exhaust being often from 10 to 20 per cent. higher than that theoretically due to the expansion of the steam from the pressure at the point of cut-off. During the period of exhaust a further evaporation takes place, and ultimately the internal surfaces are reduced to the temperature which they possessed when steam was admitted to them at the commencement of the double stroke we have been considering. Now, a very little consideration of these facts suffices to show that the real measure of the cooling of the internal surfaces which takes place, lies in the power of the material of which the cylinder is composed to produce evaporation from these surfaces during the periods of expansion and exhaust, and it is a knowledge of this fact, we presume, which has led our contemporary to suggest the mode of constructing cylinders to which we have referred. But, in making this suggestion, he has neglected to consider one other very important fact, namely, the smallness of the quantity of heat carried off by evaporation in this way at each stroke, even in non-jacketed cylinders, and hence the fallacious character of his proposal. If this quantity of heat was large in proportion to that stored up in the mass of metal forming the cylinder, then good might result from the employment of thin steel linings backed up by materials of less specific heat; but as the facts really are, the thinnest steel lining which could possibly be employed in practice would be more than sufficient to produce all the effects of the thick cast-iron cylinders now in use. An example may perhaps explain this more clearly.

Let us then consider the case of an engine which has been proved, by measurements of the water evaporated, or by other means, to be using 1,400 lbs. of steam in a certain unit of time, and let the quantity of steam used in the same time, as calculated by measurements of indicator diagrams at the points of exhaust, be 1,200 lbs. Also let the quantity of steam used have been calculated from measurements taken from the indicator diagrams at the point of cut-off; and let the quantity used per unit of time amount, when thus calculated, to 1,000 lbs. In such an instance we see that 2-7ths of the whole quantity of steam entering the cylinder per stroke must have been condensed before the point of cut-off was reached, while of this quantity $\frac{1}{2}$ was re-evaporated during the period of expansion, and the remainder was, we will suppose, evaporated from the cylinder surfaces during the period of exhaust. In adopting such an instance we have brought forward no exceptional case, but one of ordinary occurrence as all who have had much to do with "indicating" engines well know. Let us now go a little further, and imagine the engine chosen as our example to have a 30 in. cylinder, with 5 ft. stroke, and to be worked with steam of a total pressure of 75 lbs. per square inch, cut off when the piston has travelled 12 in. Taking the clearance spaces as equal to 2 in. in length of the cylinder, this cut-off would give an expansion (supposing it to continue to the end of the stroke) of $\frac{62}{14} = 4.43$ times, and the terminal pressure would be 16.9, or say 17 lbs. per square inch above a vacuum. The lowest pressure during the exhaust-stroke we shall suppose to be 3 lbs., and the temperature corresponding to the initial, terminal, and final pressures respectively, will then be, according to

Regnault, 307.5 deg., 219.4 deg., and 141.65 deg. Next, the area of the piston being 4.9 square ft., and the length of cylinder up to the point of cut-off (including clearance) being 1.16 ft., we find the steam theoretically required per stroke to be 784 cubic ft., and at 75 lbs. total pressure this quantity would weigh 1.28 lb. But we have supposed that an amount, equal to 40 per cent. of this quantity is condensed per stroke, and afterwards re-evaporated, and we thus see that this 40 per cent., the re-evaporation of which effects the cooling of the cylinder, amounts to 0.512 lb. per stroke. Now, the amount of heat carried off from the metal of the cylinder, etc., by this water during its re-evaporation, depends, in a certain measure, upon the pressure under which that re-evaporation takes place. Half the quantity we have supposed to be re-evaporated during the period of expansion, and to avoid underestimating the cooling effect, we will suppose that this evaporation takes place entirely at the terminal pressure, and shall imagine that for each pound of water thus evaporated 961.5 units of heat are abstracted from the cylinder. In the same manner we shall imagine that the half re-evaporated during the period of exhaust is all re-evaporated under the minimum pressure, the evaporation of each pound being accompanied by the abstraction of 1,015.5 units of heat from the cylinder. The mean quantity of heat abstracted from the cylinder per pound of water re-evaporated will thus be

$$\frac{961 + 1015.5}{2} = 988.5 \text{ units;}$$

and the quantity carried off by the 0.512 lb. actually re-evaporated per stroke, will be $988.5 \times 0.512 = 506.12$ units.

Next, taking the specific heat of cast-iron as $\frac{1}{9}$ that of water (an approximation sufficiently accurate for the purpose in hand), we find that the quantity of heat abstracted from the cylinder per stroke by re-evaporation would suffice to cool $506.12 \times 9 = 4{,}555.08$, or say 4,555 lbs. of cast-iron 1 deg. Now the range of temperature in the cylinder of the engine we have been considering is 165.85 deg., and if we suppose the actual surface to vary nearly through the same range of temperature, or say 160 deg., the mean variation of the whole mass effected would be about 80 deg. Dividing 4,555 by 80, we thus get 56.9 lbs. as the weight of metal heated and cooled per stroke. But such a cylinder as that we have been considering, would, with its cover, piston, and steam passages, expose an internal surface of about $53\frac{1}{2}$ sq. ft., and thus the quantity of metal cooled would be little more than a pound per sq. ft., or but about $\frac{1}{37}$ in. in thickness. Even if we suppose the surface temperature to vary but about $\frac{1}{2}$ as much as that of the steam contained in the cylinder, and the mass of metal but $\frac{1}{4}$ that amount, we should still have a thickness of but about $\frac{1}{18}$ in. affected, and this thickness, we need scarcely say, is much less than could be employed for such steel linings as our contemporary proposes to adopt. Again, supposing it possible to employ a steel lining only $\frac{1}{8}$ in. thick, this lining, together with a corresponding thickness of cover and piston, would have to vary in temperature but about $8\frac{1}{2}$ deg. to produce all the effects which it is our contemporary's object to avoid.

We are thus led to the conclusion that such systems of cylinder construction as our contemporary advocates would merely give rise to extra trouble and expense without effecting any beneficial results. The real preventative of internal condensation in cylinders is the employment of efficient steam jacketing and steam-heated pistons, and of the double-cylinder system for large measures of expansion; and this our contemporary will eventually find out as others have before him, who have dabbled in the construction or attempted construction of non-conducting cylinders. The objections we have urged to our contemporary's plans do not apply to the employment of thin steel linings fitted to cylinders, so that a space left around them forms the steam jacket. Such a method of constructing jacketed cylinders is very efficient for obvious reasons, and we hope to see its adoption extended.

A large invoice of surveying instruments was recently shipped for Japan by the well-known manufacturers, W. & L. E. Gurley, of Troy.

The Nickel Plating companies of this city are rapidly extending the applications of this branch of industry.

MECHANICAL TESTS.

From "The Artizan."

Much time and thought have been expended by some of our most competent mechanicians in devising means and apparatus for testing the strength of materials, and at the present time we certainly possess great facilities for applying various kinds of strains to any samples we may desire to experiment upon. There is, however, a matter requiring most serious consideration which has reference to the value of the tests after they are performed, and the interpretation of the results which proceed therefrom ; for experience shows that although a sample of material may withstand a certain test once or twice, yet at some future and perhaps not very distant time that same sample will rupture under a strain not equal to that applied at the time of testing, but considerably below it.

Under these circumstances, it is evident that much judgment should be used in arranging mechanical tests, and also in drawing conclusions from them as to the quality of the material examined ; wherefore we purpose devoting the present article to the subject of mechanical tests so far as they relate to iron.

Some engineers have a great objection to iron which stretches notably previous to its fracture, but for purposes where the structure in which the iron is used is liable to alterations of strain, producing vibration and concussion, this description of metal is decidedly preferable. Good bar iron for girders and bridge-work may stretch nearly but not more than 1 in. per ft. previous to fracture, and ultimately break at about 23 to 25 tons per sectional square inch. Iron which will not stretch much is usually hard, and of less ultimate strength than the softer material here alluded to. About $\frac{3}{4}$ in. as the ultimate elongation per foot may be very fairly specified for the class of work to which we are alluding, but there should be no perceptible permanent elongation (or permanent set, as it is more commonly called), until the strain has reached at least 10 tons per sectional square inch. In stretching, the bars or pieces of plate necessarily become reduced in sectional area, and it may be worthy of notice that they contract chiefly in width, and scarcely at all in thickness, if they are tolerably thin, which is probably due to the position in which they are rolled in the iron mill ; for the thickness of the bar or plate being determined by the distance of the rolls between which it is drawn, and its being squeezed through such rolls, it follows that the various layers or lamina of metal are pressed very close together, so as to strongly resist being brought into nearer proximity, whereas there being little or no pressure laterally upon the bars, the fibres are not in this direction so closely packed ; thus the bar becomes narrower more readily than thinner than it was previous to being submitted to the process of testing.

In testing structures or machines of any description especial care should be taken to guard against *over-testing*, and no test should ever be applied much in excess of the greatest strain to which the material will be subjected in ordinary work ; for if the iron be once injured the injury will be continually augmented by even moderate loads, and at last the work will give way under a strain perhaps one-half of the test load originally applied. In fact, we have no doubt that in many cases of accidents which have occurred, even after years of satisfactory working, the cause of the disaster is to be found in original over-testing of the metal inaugurating a slight flaw or lesion of the fibre which has gradually but surely increased, until at last the sectional area of the material which remains is insufficient to do even its ordinary duty.

The safe working strain on iron is about one-half the load which produces the first permanent set, and this, as we have stated above, should not occur under less tension than 10 tons per sectional square inch, or say 20,000 lbs., hence the safe working load in tension on plate or bar iron may be taken at 10,000 lbs. per sq. in. of sectional area. In compression the permanent set should commence at 16,000 lbs. per inch, therefore the safe working load would be taken at 8,000 lbs. per sq. in. of sectional area.

Now, let us see what is the proper course to pursue in testing material of which it is proposed to construct bridges or other works in iron. First, as to the terms of

the specifications, let us assume that the iron is not to stretch more than $\frac{3}{4}$ in per ft. before rupture, and not to break under 44,000 lbs. per sectional square inch. In the first place, portions taken from plates, flat bars, and angle and the irons for the purpose, should be tested in order to ascertain their qualities; this done, the iron used in the work should be examined carefully to see that there are no visible flaws in it, and if there be large masses of metal the fire test or the magnetic test may be applied to ascertain if there are within it any imperfect welds or "cold shuts" as they are technically termed; and when the work is complete it should be finally tested by loading it with the greatest load that can ever come upon it. This load should be left upon it long enough to allow the rivets, bolts, etc., to take their bearings (say 24 hours), after which it should be removed, the permanent set due to imperfect joints noted, and the load applied again, on removing which there should be no further permanent set notable. It may, however, in some cases happen that the joints will not all come down at the first loading; but there is a point in every structure at which it will cease increasing its permanent set with recurring loads, if it be sufficiently strong to do its ordinary duty satisfactorily.

Thus, to take an example to show how over-testing may lead to subsequent accident, although at the time no injury is visible from the test applied; let it be determined to test some iron to 15,000 lbs. per sectional square inch, and suppose there is a flaw in the metal which loses $\frac{1}{4}$ of its area, then the actual strain per square inch on the remaining section will be 20,000 lbs.; hence on that part the point of permanent elongation is reached, and in the course of time successive loads continue to stretch the metal until at length it gives way altogether. Now, if that metal had been tested to a little over 10,000 lbs., the load which it was intended to sustain ordinarily, the metal would not have been injured even at the defective place, but would probably have done its work satisfactorily. On the other hand, it may be said that perhaps the load of 10,000 lbs. might start an injury on some part of the structure—and even that might be the case—but still it is useless to run unnecessary risks of depreciating the strength of the material.

While speaking of the inutility of severe tests we may refer to an accident which occurred some time since to a large chain of the description known as short-linked. The chain in question was tested to a load of over 16 tons gross weight, and a few weeks after snapped under a load which did not exceed 8 tons. The fractured link exhibited a cold shut, showing that half the area of metal in the link was lost. A portion of the same chain tested to fracture showed an ultimate strength of over 25 tons gross load.

In our opinion, in respect to the question of chains a portion of any given chain should be cut of and tested to its breaking strain, and the remainder, or that part which is intended to be practically applied, should be tested to a load but slightly exceeding that to which it will be habitually exposed; and subsequently it should be submitted to the fire-test, which is conducted as follows:—The chain is gradually passed through a smith's fire, and every link carefully examined when at a clear red heat, water being poured on each link, when any defective shut is sure to show itself, and all defective links must be cut off, and replaced by sound ones. With chains thus examined we have never had an accident in use, but have sometimes found two or three bad links in a length which had passed the ordeal of a licensed testing-house, thus showing that the ordinary chain test (unfortunately too much relied upon) is, in a practical sense, no guarantee at all of the safety of the chains tested, which, by the way, might be further instanced had we space to multiply examples.

The remarks made above on the over-testing of iron girders will of course equally apply to wrought-iron boilers, and, indeed, it seems absurd to test a boiler up to a pressure of 80 or 90 lbs. per square inch, which in actual working will never contain more than 30 lbs. per inch, and this is another instance of trying to be too sure.

We will now pass on to the question of testing cast-iron girders. Here it may very easily be shown how important it is that the metal should be sufficiently elastic to allow of a notable amount of deflection before fracture, and more especially if the case of a sudden concussion be taken for example. If a body falls a certain distance it acquires a corresponding

amount of *accumulated work*, supposing there had been no resistance to its motion while falling; and this work is represented by its weight multiplied into the distance through which it has fallen. Let the weight equal 10,000 lbs. and suppose that the height of its fall is 40 in., then the amount of accumulated work acquired by the mass during its fall will be—

$$100{,}000 \text{ lbs.} \times 40 \text{ in.} = 400{,}000 \text{ inch-pounds.}$$

that is to say, work equal to 400,000 lbs. raised 1 in. high.

Let us now assume that there are two cast-iron girders of equal ultimate strength, that is to say, that they will both break with the same weight *laid* upon them *gradually*, but that one deflects 2 in. and the other 3 in. previous to rupture, that is to say, the latter deflects under a given load 50 per cent. more than the former, we shall find the one that deflects most suffers least from the blow of the falling weight. The amount of accumulated work in a body being known, and the distance through which it has to pass in *expending* such work, the force or pressure is ascertained by dividing the accumulated work by such distance. Now, the distance through which the weight has to pass is represented by the deflection of the girder, consequently in the two cases we have the following means, loads, or pressures on the girders :—

First girder—Mean load due to concussion $= \frac{400{,}000}{2} = 200{,}000$ lbs.

Second girder—Mean load due to concussion $\frac{400{,}000}{3} = 133{,}333$ lbs.

Hence the girder which deflects most suffers least mean load from the fall of a weight upon it, and what is true of a concussion thus produced must be true of all concussions.

Having thus set forth the practical conclusions to be drawn from mechanical tests, we shall close the present article, but probably shall before long resume the subject.

A New Inextinguishable Storm and Danger Signal Light.—This new signal, possessing most remarkable properties, has now been brought before the public. It was first exhibited at the President's meeting of the Royal Society on 22d April, when it attracted great attention. The peculiarities of the signal light are, that it is self-igniting when placed in water or thrown on the sea. Contact with water being the only means of igniting the lamp, it is inextinguishable when once ignited ; neither wind nor storm has any effect upon the flame. The light is of intense brilliancy, and of great duration, and can be seen for a great distance in the open air. Photographs may be taken by the light of this new signal. Experiments were tried on the evening of 25th April, at 10 o'clock, in the presence of some scientific gentlemen, to determine its brilliancy as a signal. A lamp was placed in a bucket of water on the top of Primrose Hill, and the light was so intense that after the signal had been burning for 20 min. small newspaper print could be distinctly read at a distance of 70 ft., notwithstanding that the night was thick and foggy. This new signal light will burn for over 40 min. In construction the lamp is exceedingly simple, and so contrived that when once burnt the whole may be thrown away. The chemical preparation contained in the lamp is a solid, hard substance, free from danger; not affected by heat, and so non-explosive; and the signal is comparatively inexpensive. Its applications for marine signals are numerous. In case of shipwreck a few lamps thrown on the sea would illuminate the entire scene, and enable assistance to be promptly and efficiently rendered. For rocket-line apparatus it is equally valuable, as, bursting into a flame on falling into the sea, it would indicate the position of the rocket-line. In connection with life buoys it would be a mark to the drowning sailor. In life-boat services it would be a signal to the vessel in distress, and the brilliant light would greatly assist in the rescue. In cases of salvage, ships' signals, tide and harbor warnings, the duration of the light renders this new invention of great value. As a railway signal, to be used by the guards and station porters in cases of accident, it is equally available, and will be of great utility. The difficulties of preparing the chemical compound have been entirely overcome by Messrs. Albright and Wilson, of Oldbury, the contractors for the manufacture of the lamp for Mr. Nathaniel Holmes, the patentee.—*Nature.*

NOTES ON LIME, MORTAR, AND CEMENT.

From "The Engineer."

A pamphlet has been published at Allahabad, by Mr. William Sanderson, C.E., executive engineer, irrigation branch of the Public Works Department, upon the subject of cement and mortar, with special reference to their use in the works under construction by the Department. The subject, especially that part of it which has reference to the natural cement stones, is of importance to engineers in India, and we therefore make the following extract from Mr. Sanderson's little work :—

It is admitted by the engineers of the irrigation branch of the Public Works Department that the best hydraulic mortars and cement are desiderata for the masonry of all irrigation works, especially the Ganges Canal. For heavy masonry works of all classes it would be of great advantage to be enabled to use hydraulic cement in some proportion with ordinary mortar.

Regarding this important subject of materials for mortars, it may be observed that in the remains of ancient works, both in the East and West, it has been well ascertained that the best mortars were prepared by the admixture of lime, with pounded brick or tile; yet in this country there are examples of the carelessness of observation of English engineers on the Great Indian Peninsula Railway and other works. The specifications of the Great Indian Peninsula Railway were for mortar one part lime and one part sand. Near the Western Ghauts it is possible that good mortar may have been made, because the sands are from the denudation of trap rocks; but as the work progressed further inland the sands procurable were inert. The result of neglect in drawing up the specifications was the necessity for reconstruction at a cost of a million sterling. There can be no doubt that the failure of the masonry works arose in a great measure from weak mortar. Fortunately, in some districts distant from Bombay, the kunkur from which lime was made contained the requisite ingredients for good mortar, the geological formation being different. In the Toombgee and Talikot lands of the Sholapoor district there are extensive argillaceous deposits from which combinations with carbonate of lime would form good kunkur. There are also fields of dolomite, granitic rocks, and other formations, from which the sands of the several nullahs are derived. The works on the south-eastern extension of the Great Indian Peninsula Railway beyond Sholapoor are superior to other works on that railway, in consequence of the natural store of suitable material for the best kinds of mortar. The inattention to the provision of suitable ingredients for good mortar at home arises, in a great measure, from the absence of any inducement to inquire into the subject, it being customary to specify a particular quality of lime and other materials from known localities, the business of preparing lime having become a separate branch of trade; and so strong is habit that the form of specification suited to English works is copied for works of distant countries. In India the clearest specifications for mortar are drawn up by engineers whose acquirements and practice are wholly Indian; but so strong is habit, that engineers of home training and Indian practice have been known to send to England for Portland and other hydraulic cements, with vast quantities of material at hand, or procurable within a practicable distance in India. The disaster of Allahabad calls for a wider inquiry than was made by the committee whose object was the cause of that especial failure. An inquiry should be instituted throughout the country as to the sources from which the lime used in public buildings is drawn and the *modus operandi* of its application.

After devoting a chapter to a discussion on materials, with rough methods of analyzing them, the author proceeds to consider the natural cement deposits :—

The pressing necessity for the best cementing materials for the vast system of irrigation works has impelled Government to direct experiments in various parts of India, but such as have been reported are inconclusive, or are a repetition of experiments from which practical conclusions have been drawn long ago in Europe. Some of these experiments are published by Government. The last, No. 206-141, of 1870, is a note by Mr. Tanner,

M. I. C. E., to superintending engineer, Sirhind Canal, containing some useful information about concrete, especially recommending the use of material broken small before mixing with lime, etc. It has been known and practised for 35 years, in France particularly, where béton for strong work of small dimensions is composed of lime, trap, and stone, broken to pass a $\frac{1}{2}$ in. ring; béton thus composed is "rammed," precisely as was done by Mr. Tanner. Another piece of advice is given by that gentleman, and also by Mr. Palmer, an executive engineer, which is worth all the 9 pages of foolscap containing their report, viz., that "lime should be used fresh, and that not more than 4 days' consumption should be prepared at once."

For several years these experiments and research have occupied the thoughts and leisure of engineers employed on Indian irrigation works, but the result has hitherto been small; and so difficult is it to break off old habits, that an executive engineer in 1868 sent in a requisition for 1,000 maunds of Portland cement for the annual repairs of his division of irrigation works. This was casually mentioned by Col. Brownlow, superintending engineer, to Mr. Sanderson, a civil engineer, who had come out to serve for 5 years in the Public Works Department under a covenant with the Secretary of State for India, and to that casual communication is due the experiments and research which has led to the discovery of an extensive deposit of argillaceous limestone near the head of the Ganges Canal at Hurdwar.

On Mr. Sanderson's statement, that Portland and Roman cements were greatly deteriorated by long sea voyage, and that numerous failures had resulted from the transport of hydraulic cements to colonial and Indian ports, and that material could be obtained in any quantity for the manufacture of artificial hydraulic cement, Col. Brownlow directed him to draw up a memorandum on the subject, and Mr. Sanderson accordingly commenced an examination of the limestone boulders of the bed of the Ganges at Hurdwar, and found specimens of true cement stone, being fragments detached from beds of argillaceous limestone, rounded by attrition. After small experiments with pure limestone with clay, and the specimen of cement stone, the "first memorandum*" was submitted on the 28th June, 1868, and an application was made by Col. Brownlow for the sanction of Government to expend 1,050 rupees in experimental manufacture of artificial hydraulic cement at Azofnuggur, about 4 miles from Roorkee, where is a fall of $8\frac{1}{2}$ ft., a locked channel on which are placed corn mills, and there was a turbine for lifting water, which was to be repaired and turned to use in moving the incorporating and pulverizing machinery necessary for the economical manufacture of cement. The sanction of Government was obtained, and Mr. Sanderson was directed to conduct the experiment. No notice was taken by Government of the reference to the natural cement stones, but orders were given to manufacture artificial hydraulic cement.

Mr. Sanderson was called away from Roorkee elsewhere, and the management of the experiment devolved upon persons who were not interested in it, and who did not view with satisfaction what was considered an innovation, and a year after the Government order on the subject, Mr. Sanderson having returned to Roorkee, and being directed to continue the experiment, found that the kiln had been built without care or supervision, and it had to be taken down and rebuilt—the turbine had not been repaired and placed in position—in fact it had been wholly removed. No incorporating machinery had been provided, and in August, 1869, Mr. Sanderson resumed the experiment of manufacture by primitive and costly process, and brought it to a conclusion by the production of 350 cubic ft. of cement in lump and 200 cubic ft. lime at a cost of 550 rupees, in addition to what had been previously expended.

On completion of the experimental manufacture the second memorandum was submitted to Government, in which was repeated the assertion that natural cement stones were procurable in sufficient quantity, and that the cost of incorporation of ingredients could be avoided.

Colonel Brownlow had been succeeded by Captain Moncrieff, R. E., as superintendent engineer, who wrote officially (when forwarding Mr. Sanderson's "second memorandum") in reference to the reported discovery of natural cement

* The memoranda alluded to are published by Mr. Sanderson in an appendix to his work.

stones in the Sewaliks and Dehra Dhoon, that he thought the probability was against the natural cement stone being found, because the experienced geologist, Sir Proby Cautley, who was so intimately acquainted with the Dhoon, would have discovered it, could it have been found. This was certainly not very encouraging. Indeed it was rather derogatory to Mr. Sanderson to have his assertion doubted, and the doubt exhibited in an official communication, he was instructed to frame an estimate of the machinery necessary to establish a cement manufactory at Azofnuggur, but no distinction was drawn between a manufactory of artificial hydraulic cement and that for the pulverization of natural cement stones. The cost of machinery for artificial hydraulic cement to that of simple pulverization of calcined natural cement stone is as 3 to 2, and the cost of working as 3 to 1.

In reply to the superintending engineer's letter, in which he expresses a doubt as to the assertion by Mr. Sanderson that he had found natural hydraulic cement stone procurable in large quantities, the chief engineer wrote an official, enclosing a printed report showing that Mr. Sanderson was unfortunate in his endeavors to serve the State.

It is not considered proper to publish official letters without Government sanction, therefore Mr. Sanderson confined himself to saying that he wrote in reference to the enclosing official letter, to the effect that he merely, in obedience to Colonel Brownlow's instructions, wrote the "first memorandum," and that on taking charge of the experiment in August, 1868, he had nothing to do with disbursement, nor had he any control over expenditure beyond limiting the number of laborers to actual requirements, and that the cost of the experiment appears to have been much increased by a want of supervision and by altering the original arrangements as suggested in the "first memorandum," and to which special reference was made in his "second memorandum."

Although discouraged by the expressions of dissatisfaction of the Government, North-western Provinces, and of doubt as to the truth of his assertions as to the discovery of natural cement stones, Mr. Sanderson continued his research and experiments, with a view to a publication, to bring to the general notice among the civil engineers, and others connected with the works in progress over a large area, that the material called Portland cement can be manufactured in India, and used fresh at a third of the cost at which it is brought to Calcutta from England. With proper machinery artificial cement can be manufactured for 12 annas per cubic ft., the average cost of Portland cement being 2.4 rupees per cubic ft. It is not the present object in this paper to advocate the manufacture of artificial hydraulic cement, but to show by what steps the discovery of natural cement stone in the Sewaliks and Dehra Dhoon was made, and to bring to notice that there is abundance of material near Hurdwar.

It has already been shown that specimens of natural cement stone were found in the Ganges bed in May, 1868, experimented upon and reported to Government. Also, that while experimenting on the manufacture of artificial hydraulic cement in August and September, 1869, at Azofnuggur, a few bushels of natural cement stones were tried, and the specimens, raw and prepared, were sent to the superintending engineer to be submitted to Government.

In the beginning of 1870 further specimens were collected from the Jhakun Rao, near Bhogpoor, at the foot of the Himalayas; upon these, and samples of kiln-core, from Kunkul and Hurdwar, experiments were made, and the results communicated to the superintending engineer, but with no result in obtaining any recognition of the fact of the discovery of natural cement stones in sufficient quantities in the Dehra Dhoon; and in May, 1870, having completed certain surveying duties, Mr. Sanderson set out to make a personal inspection and a careful exploration, and on the 9th May reported to the superintending engineer the existence of beds of argillaceous limestone of considerable extent close to the town of Hurdwar and to the head of the Ganges Canal, and submitted to him plans for the necessary machinery for pulverizing the calcined cement stone, with estimates, etc., accompanying a memorandum.

Again, the superintending engineer wrote to Government to say that he could not alter his opinion, that it is very unlikely that Sir Proby Cautley should have missed a good natural cement procurable to any

extent in the Dehra Dhoon; but he admitted that Mr. Sanderson had collected more specimens, and considered that he had proved his point. He also directed the chemical analyst to make a report, and Mr. Sanderson presented Dr. Murray Thompson with 3 specimens of natural cement stone for that purpose.

The argillaceous limestone thus discovered lies in a spur of the Himalayas, near Bhogpoor. Large quantities of cement stones of several kinds are procurable in the Jhakun Rao, the bed of a mountain torrent issuing from the Himalaya, near Bhogpoor, but the most valuable discovery of all was argillaceous limestone beds near Hurdwar.

Mr. Sanderson took a quantity of the Hurdwar cement stone to Muhewar (a canal store depot 3 miles from Roorkee), and prepared about 25 cubic ft. of cement powder, and of this 3 in., 2 in., and 1 in. cubes were formed by lever pressure of 800 lbs., and immersed on the 15th June, 1870. Pairs of bricks were joined, and other forms for trial were prepared and immersed, and in July, 1870, he reported this preparation for the several tests of the Hurdwar cement, and referring to the singular continuance of doubt on the subject, he suggested that Government should order a committee to assemble to inspect the argillaceous limestone beds near Hurdwar, to make the tests for adhesive and cohesive properties, and report to Government. He also suggested that about 10 cubic ft. of the cement powder should be distributed among the executive engineers for test as to time of setting and of induration, and of the extent of induration after 30 days' immersion in water. In reply the superintending engineer simply told Sanderson to send the cement to the several executives, and this was done on the 19th August, 1870.

No notice having been taken, and as the season was advancing, Mr. Sanderson proceeded to make the tests for the adhesive property of the Hurdwar cement, and submitted the results to the superintending engineer for the information of Government, as follows:

"Referring to memoranda dated 7th May and 20th July, forwarded to the Superintending Engineer, 1st Circle Irrigation Works, North-Western Provinces, for the information of Government, Mr. Sanderson states that he has made the trials, suggested on the 20th July to be intrusted to a committee, and now submits a list of experiments on the adhesive properties and tenacity of hydraulic cement, obtained from the Sewalik spurs near Hurdwar. One preparation being a pair of bricks, joined crossways by $\frac{3}{16}$ in. thickness of cement, has undergone a trial to the extent of 1,037 lbs. without being ruptured, the area of joint being $20\frac{1}{4}$ sq. in., the strain applied was $50\frac{1}{2}$ lbs. per sq. in. This preparation (No. 4 of the experiments) is forwarded to the superintending engineer. Experiment No. 5, made with the assistance of Lieutenant G. Hildebrand, R. E., showed an extreme of adhesive power—1,054 lbs. or $\frac{1054}{20\frac{1}{4}} = 52\frac{1}{4}$ lbs. per sq. in.

"Of the specimens forwarded herewith, No. 3 is a 3-in. cube of sand and cement in equal parts; No. 9 of experiments was on a preparation of joint $\frac{1}{4}$ in. in thickness, and area $20\frac{1}{4}$ sq. in. The weight applied was 547 lbs., showing adhesiveness of 27 lbs. per sq. in.

"The other specimens are cubes of pure cement prepared for trial of crushing power.

"Specimens of the raw and burnt stone of cement powder, and of preparations have been placed in the museums of Roorkee and Calcutta.

"List of specimens forwarded to the superintending engineer with the foregoing report of experiments for information of Government, dated 4th November, 1870 —(1) A pair of bricks joined crossways, age of joint 105 days, No. 4 of list of experiments; (2) the broken mass of cement, No. 9 of list of experiments; (3) a 3 in. cube of cement and sand in equal parts; (4) a 3 in. cube of neat cement; (5) a 2 in. cube of neat cement; (6) a 1 in. cube of neat cement."—(See p. 208.)

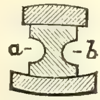
The note, with report of experiments and specimens, was not acknowledged, and Mr. Sanderson then sought for a means of testing the resistance to crushing. This was found in the hydraulic press of Roorkee workshops, which was repaired, put in order, and kindly offered for use by Mr. A. Campbell, the superintendent, who had the press worked and assisted at the trial.

The test for crushing power was reported as usual to Government; 3 trials gave a mean of 497 lbs. to the sq. in.; the

press was somewhat out of order, and required care in working to ascertain the amount of pressure ; one of the cubes appeared to have required 720 lbs. to the sq. in. ; this was not taken for the mean ; it may be fairly stated the resistance to crushing power of Hurdwar cement is 500 lbs. per sq. in. This, the final communication, is dated 19th November. No notice was taken by Government after January, 1870, nor by the superintending engineer after May, 1870 (except to give instructions to distribute samples of the cement to executive engineers), of the several letters, memoranda, reports of experiments, and frequent communications of all sorts on this important subject ; neither have the executive engineers to whom specimens were forwarded, acknowledged receipts of them, or noticed in any way the note accompanying the despatch.

Tabular Statement of Experiments on the Adhesive and Cohesive Power of Hydraulic Cement, prepared from the Stone procurable at Hurdwar, and described in Mr. Sanderson's Memorandum, dated 7th May, 1870.

MUHEWAR, near ROORKE, 28*th October*, 1870.

Number of Experiments.	Date of Experiment.	Weight applied.	Form of Preparation.	Age of Cement.	Remarks.
				Days.	
1	18th Oct., 1870	1020	Pair of bricks joined crossways, 1-16 in. joint.. .	132	Joined, not sundered—50lbs. per sq. in.
2	Do. do.	170	Pair of stone—Hurdwar sandstone—size of brick-cement 1-16.....	132	The suspending wire to weight tray broken, joint sundered by concussion.
3	20th Oct., 1870	1020	Pair of bricks joined crossways, cement 1-16.....	125	Joint sundered, face of brick partially detached.
4	Do. do.	1037	Do. do. do.	105	Joined, not sundered—51 lbs. per sq. in.
5	22d Oct., 1870	1054	Do. do. do.	132	Clear separation of cement from brick—52½ lbs. per sq. in.
6	Do. do.	544	Do. do. do.	105	Cement broken, defective joint, air cavity.
7	25th Oct., 1870	977	Agra sandstone, pair size of bricks, cement 1-16..	132	Clear separation of cement from stone—48 lbs.
8	Do. do.	816	Pair of bricks joined crossways..................	105	Face of brick torn off—40 lbs.
9	Do. do.	547	Joint of cement 1 part, sand 1 part, pair of bricks crossways.............	105	Clear separation of mortar from brick—27 lbs. per sq. in.
10	18th Oct., 1870	203	Cement mass.  Area of section on *a*, *b*, two square inches......	132	A test of the tenacity of the cement, proving it to be 101½ lbs. per sq. in.

Whether it is that the officials of the D. P. W., from the highest to the lower grades, are overwhelmed with the enormous quantity of office detail, in docketing, minuting, code-form work, and intricate forms of accounts, or that a general feeling of dislike to innovation prevails in the department, certain it is that there is more difficulty in obtaining recognition of a valuable material newly brought to notice than in England, where settled trades and vested interests have to be contended with. It is not simply the repeated notices and assertions in reference to the valuable cement stone procurable at Hurdwar fail to draw attention, but the whole subject seems distasteful and meets only neglect, as the following will show :—

The chief engineer, in his printed re-

port, dated 18th January, 1870, on the experimental manufacture of artificial hydraulic cement, ordered by Government in August, 1868, says : "It appears that the work which the chief engineer was constantly urging should be pushed on, was carried on intermittently and without interest by Mr. H., who," etc.

This was in reference to the building of a kiln at Azofnuggur for the burning and incorporation of lime and clay in this important experiment.

The kiln had been designed in June, 1868, by Mr. Sanderson, on Mr. Vicat's principle of alternate fires ; it was not built to plan, and was in August, 1869, carefully rebuilt ; as it was but experimental, the fire-pits and the parts connected were of sun-dried bricks in clay. It was surmised that continual burning would bake the inside, and whatever damage the outside sustained by weathering could be easily repaired by packing up with moistened clay. On the sun-dried brick in clay basement a rim of kiln-burnt brick in mortar was laid, and above the rim the cupola was built of kiln-burnt brick in clay. This structure was left in good repair after completing the experimental manufacture of hydraulic cement in November, 1869.

There was also an old turbine in the mill waste chamber of the lock at Azofnuggur, which Mr. Sanderson had proposed to utilize in the experiment, as the motive power to the incorporating and pulverizing machinery. It has already been stated that this turbine was not made available for the experimental manufacture, on completion of which 350 cubic ft. of cement were placed in a shed, and it was strongly urged that the cement should be used in the annual repairs of the Ganges Canal. See also in second memorandum, even if it was not ready for use in 1869 it could have been stored in bulk and pulverized for use at the time of the same repairs in 1870.

The same "want of interest," of which the chief justly complained, was manifest in the neglect of the Azofnuggur cement works. Mr. Sanderson went to inspect them little more than a year after he had completed the experimental manufacture, and found the kiln falling into decay; the work had stood well, but the mass of sun-dried brick was channelled by flow of rain-water. The turbine was removed, and the frame-work half washed away, the mortar troughs and mill covered with vegetation. In the troughs 200 to 300 cubic ft. of lime had been suffered to become waste, and the 300 cubic ft. of cement had been left to the action of rain and wind, and was utterly spoiled ; yet with reference to it the chief engineer had reported on 18th January, 1869, that "the cohesive property of the cement at any rate is good." This 300 cubic ft. of cement represented a value of 267 rupees, and the kiln 287 rupees, and it can be shown that the artificially manufactured cement had the highest hydraulic properties.

This utter neglect of a matter of the highest importance to the Public Works officials, and of the interests and property of Goverment, can only arise from sheer inability to spare any time or thought from the multiplicity of detail that weighs on the professional officials of the Public Works Department.

Seventy or eighty years ago Mr. Parker made cement from nodules found in the Isle of Sheppey ; he was the first to recognize the valuable combination of the proper ingredients in the natural cement stones ; he had to contend with ignorance and prejudice, but without any aid from high authority he shortly succeeded in forcing a market for his new material, which he called "Roman Cement," because the Romans were known to have used hard water-resisting cements made from similar substances. Other names have been added, and we have "Atkinson's," "Frost's," Medina's," etc., cements, but they are all similar to each other, from various argillaceous limestone formations. The trade has grown so enormously that the septaria or nodules of argillaceous limestone found near Harwich alone supply annually 1,800,000 cubic ft. of cement powder.

The Hurdwar cement stone is found in beds under the foot of the Sewaliks, which are composed of upheaved strata of indurated sand, between which are the thin beds of argillaceous limestone. In the district close to the town of Hurdwar, these beds vary in thickness from 2 ft. to 9 ft., and they can be worked so as to prepare the material close to the bank of the navigable stream leading to the Ganges Canal head. Abundance of fuel is in hand, and if a fair arrangement with

the forest department could be effected the cost of fuel suitable for the kilns would not be more than 10 rupees per hundred maunds, as the smaller wood and spray is as valuable as the heavier wood sold to the railway companies. The coarse reed-grass, dead leaves, vegetable refuse of all sorts, by an arrangement could be brought into use with good effect.

The Hurdwar stone contains :—

Carbonate of lime	51	100
Silica and alumina, and other matter.	49	

A minute chemical analysis has not been yet obtained ; the quantity of carbonate of lime was ascertained by the fire and muriatic acid tests.

The stone should be burnt in conical kilns just sufficiently to drive off the water and carbonic acid. It loses 30 per cent. in its weight in the process ; the calcining should, therefore, be done at Hurdwar to save carriage of fuel and superior weight of raw stone. The calcined stone should then be removed to Azofnuggur, or to one of the falls on the Ganges Canal, where water, as a motive power, would be available, and after thorough pulverization, by machinery in a pan containing a pair of rollers, it should be put in sacks or casks.

The cost of Hurdwar cement is estimated as follows :—

Say, 500 cubic ft. of argillaceous limestone, quarried and loaded in kilns, at 6 rupees per 10 cubic ft.	30	0	0
450 maunds fuel at 10 rupees per 100 maunds	45	0	0
Two laborers, 20 days=40, at 3 annas per day	7	8	0
Ten woodcutters, 10 days=10×10=100, at 2 annas each	12	8	0
Boat and lading charges, 20 miles, 400 maunds	7	12	0
Proportion of cost of machinery, wear, etc	6	0	0
Two skilled workmen, 3 days=6, at 6 annas each	2	4	0
Payable to Dehra Dhoon authorities, 400 maunds, at 6 rupees per 100 maunds	24	4	0
Cost of 600 cubic ft, cement powder.	135	0	0

or a little over 22 rupees per 100 cubic ft., that is, if the abundance of fuel will be by permission of Government available. At any rate the cost would not be more than 30 rupees per 100 cubic ft., as estimated in the beginning. The average cost of Portland cement at Calcutta is 9 rupees per barrel containing 5 bushels or $4\frac{1}{4}$ cubic ft.; this would give 200 rupees per 100 cubic ft.

Hurdwar cement, with all the valuable properties, equal to Portland and Roman cements from England and at 15 per cent. of the cost at Calcutta of the latter, can be delivered at any place on the Ganges Canal, plus the cost of carriage by boat from Roorkee ; and it is to force this fact, which has not been recognized by the Government, North-west Provinces, on the attention of those engaged in the construction of public works in this country, that this note has been prepared for circulation.

At extreme distances, where increased cost of carriage would be an obstacle to the use of Hurdwar cement, artificial hydraulic (Portland) cement, which may be considered to be an improved hydraulic lime, and occupies an intermediate position between the best hydraulic limes and the fine "Hurdwar" natural cement, could be manufactured from preparations of pure lime and clay, both ingredients being generally procurable ; the cost of this manufacture being about 60 rupees per 100 cubic ft.

Steam Engines at Milan.—The number of steam-engines at Milan has been greatly increased within the last few years, and there are now double the number there were three years ago. In 1850, there was only 1 steam-engine at work ; 10 years later (1860), 17 ; in 1864, 24 ; in 1867; 37, and at the present time 74. In the commune of the Corpi Santi, which comprises all the suburbs of Milan, and containing a total population of 60,000 persons, the number of steam-engines is 45. One of Howard's patent boilers is now being put up at a large distillery in Milan.

The cost of the drainage works of Calcutta, so far as they are at present completed, has been about £470,000, including £25,000 paid for land. The system consists of 3 classes of sewers. The large ones, or those of the first-class, are five in number, and go down the main thoroughfares ; into these a smaller, or the second-class drains, are carried ; whilst the third-class, or smallest of all, take in the drainage from the narrow lanes.

THE GENERAL OCEANIC CIRCULATION.

From "Nature."

Among the results of the Porcupine Expeditions of 1869 and 1870, there are perhaps none more important than those relating to the Temperature of the Deep Sea. For it is only to such accurate determinations of ocean temperatures as have now been made for the first time, not only at the surface and the bottom, but also at intermediate depths, that a really scientific theory can be framed of that great Oceanic Circulation, which, while it eludes all ordinary means of direct observation, seems to produce a far more important effect, both on terrestrial climate and on the distribution of the marine fauna, than that of the entire aggregate of the surface-currents which are more patent to sight. The latter usually have winds for their prime motors, and their direction is mainly determined by the configuration of the land; so that their course and action will change with any superficial alteration which either opens out a new passage or blocks up an old one. The former, on the other hand, depending solely on difference of temperature, will (to use Sir J. Herschel's apposite language) have its movements, direction, and channels of concentration mainly determined by the configuration of the sea-bottom; and vast elevations and subsidences may take place in this, without producing any change that is discernible at the surface.

The history of the doctrine of the general oceanic circulation has been recently given in the Anniversary Address of the President of the Geological Society, with a completeness which (so far as we are aware) had never been previously paralleled. But this doctrine has hitherto rested on the very insecure foundation of observations which were alike inadequate and inaccurate; and it has consequently been discredited, both by physicists and by physical geographers. It is now impossible to assign a precise value to the older observations upon deep-sea temperatures. For it was shown by the careful experiments which were made by Mr. Casella two years ago, under the direction of the late Prof. W. A. Miller, Dr. Carpenter, and Captain Davis of the Admiralty, that the pressure of sea-water at great depths on the bulb of the thermometer—a pressure amounting to about a ton per sq. in. for every 800 fathoms—exerts so great an influence on even the very best instruments of the ordinary construction, as to cause a rise of 8 or 10 deg. under an amount equivalent to that which would be exerted at from 2,000 to 2,500 fathoms' depth;* and the error of many thermometers under the same pressure was two or three times that amount. There is reason to believe that some of the thermometers formerly employed, especially in the French scientific expeditions, were protected against that influence; but no such protection appears to have been applied to the thermometers supplied to Sir James Ross's Antarctic Expedition; and the observations by which he supposed himself to have established the existence of a uniform deep-sea temperature of about 39 deg., now seem to have been altogether fallacious. So again, Captain Spratt's observations in the Mediterranean, though made with great care, were seriously vitiated by this source of error.

It appears from Mr. Prestwich's exhaustive summary, that as long ago as 1812 Humboldt had maintained that such a low temperature exists at great depths in tropical seas, as can only be accounted for by the hypothesis of under currents from the Poles to the Equator. And this view was adopted by D'Aubuisson, Lenz, and Pouillet; the latter of whom considered it certain "that there is generally an upper current carrying the warm tropical waters towards the Polar seas, and an under current carrying the cold waters of the Arctic regions from the Poles to the Equator." Our Arctic navigators had met with temperatures in the Polar seas as low as 29 deg. at 1,000 fathoms; and these observations have been more recently confirmed by those of M. Charles Martins and others in the neighborhood of Spitzbergen. Several instances are recorded, on the other hand,

* Mr. Prestwich cites Dr. Carpenter as estimating the error from pressure "at 2 deg. or 3 deg. or even more." The error is said by Dr. Carpenter to have been from 2 deg. to 3 deg. on the depths of from 500 to 700 fathoms first explored; but would have been from 8 deg. to 10 deg. at the depths subsequently reached.

in which temperatures of from 38 deg. to 35 deg. were observed at great depths nearly under the Equator; and this alike in the Atlantic, Pacific, and Indian Oceans.

The temperature soundings taken in the Lightning and Porcupine Expeditions, with trustworthy instruments, have shown:—(1) That in the channel of from 600 to 700 fathoms' depth which lies between the North of Scotland, the Orkney and Shetland Islands, and the Faroes, there is an upper stratum of which the temperature is considerably higher than the normal of the latitude; whilst there is stratum occupying the lower half of this channel, of which the temperature ranges as low as from 32 deg. to 29.5 deg.; and a "stratum of intermixture" lying between these two, in which the temperature rapidly falls—as much as 15 deg. in 100 fathoms. (2.) That off the coast of Portugal, beneath the surface-stratum, which (like that of the Mediterranean) is super-heated during the summer by direct solar radiation, there is a nearly uniform temperature down to about 800 fathoms; but that there is a "stratum of intermixture" about 200 fathoms thick, in which the thermometer sinks 9 deg.; and that below 1,000 fathoms the temperature ranges from 39 deg. down to about 36.5 deg. (3.) That in the Mediterranean the temperature beneath the super-heated surface-stratum is uniform to any depth; being at 1,500 or 1,700 fathoms whatever it is at 100 fathoms, namely from 56 deg. to 54 deg., according to the locality. To these may be added (4) the observations recently made by Commander Chimmo, with the like trustworthy thermometers, which, in lat. 3 deg. 18½ min. S., and long. 95 deg. 39 min. E., gave 35.2 deg. as the bottom temperature at 1,806 fathoms and 33.6 deg. at 2,306 fathoms. These seem to be the lowest temperatures yet observed in any part of the deep ocean basins outside the Polar area.

It is clear, therefore, that very strong evidence now exists, that instead of a uniform deep-sea temperature of 39 deg., which, on the authority of Sir James Ross, by whom the doctrine was first promulgated, and of Sir J. Herschel, by whom it was accepted and fathered, had come to be generally accepted in this country at the time when the recent deep-sea explorations commenced, not only is the temperature of the deeper parts of the Arctic basin below the freezing-point of fresh water, but the temperature of the deepest parts of the great oceanic basins, even under the Equator, is not far above that point. And it seems impossible to account for the latter of these facts in any other mode than by assuming that Polar water is continually finding its way from the depths of the Polar basins along the floor of the great oceanic areas, so as to reach or even to cross the Equator. And as no such deep efflux could continue to take place without a corresponding indraught to replace it, a general circulation must be assumed to take place between the Polar and Equatorial areas, as was long since predicated by Pouillet.

Such a vertical circulation, it was affirmed by Prof. Buff, would be necessarily caused by the opposition of temperature between the Equatorial and the Polar seas; and this view was adopted by Dr. Carpenter, in his "Porcupine" Report of 1869, as harmonizing with the temperature-phenomena which had been determined in the expedition of that year. It has been since contested, however, not only by Mr. Croll and Dr. Petermann, but also by Dr. Carpenter's colleague, Prof. Wyville Thomson, all of whom agree in regarding the amelioration of the temperature of the Arctic Sea as entirely due to an extension of the Gulf Stream, the underflow of Polar water being merely its complement. And the authority of Sir John Herschel was invoked against the idea that any general oceanic circulation could be maintained by difference of temperature alone; though his statements, when carefully examined, only go to prove that no such difference could produce *sensible currents.*

Such was the state of the question when the Porcupine Expedition of last year concluded its work; and the results obtained, while confirmatory of previous observations, suggested to Dr. Carpenter a definite Physical Theory, which now comes before us with the express approval of the great philosopher who had been said to be opposed to it.

Having ascertained, as our readers have learned from his report, the existence of an outward under-current in the Strait of Gibraltar, which carries back into the Atlantic the water of the Medi-

terranean that has undergone concentration by the excess of evaporation in its basin, Dr. Carpenter applied himself to the consideration of the forces by which the superficial in-current and the deep out-current are sustained; and came to the conclusion that, as had been previously urged by Captain Maury, a *vera causa* for both is to be found in excess of evaporation, which at the same time lowers the level and increases the density of the Mediterranean column as compared with a corresponding column of Atlantic water. This conclusion, when scientifically worked out, was found to be applicable, *mutatis mutandis*, to the converse case of the Baltic Sound; in which, as was long ago experimentally shown (with a result that has recently been confirmed by Dr. Forchhammer), a deep current of salt water flows inwards from the North Sea, whilst a strong current of brackish water sets outwards from the Baltic, the amount of fresh water that drains into which is greatly in excess of the evaporation from its surface.

Comparing, then, the Polar and Equatorial areas, it is shown by Dr. Carpenter that there will not only be a continual tendency in the former to a lowering of level and increase of density, which will place it in the same relation to the latter as the Mediterranean bears to the Atlantic; but that the influence of Polar cold will be to produce a *continual descent* of the water within its area; thus constituting the *primum mobile* of the General Oceanic Circulation, of which no adequate account had previously been given. This conclusion, as our readers will have seen, has been most explicitly accepted by Sir John Herschel.

Our limits do not admit of our following Dr. Carpenter through his discussion of the relative shares of the Gulf Stream and of the General Oceanic Circulation in that amelioration of the temperature of the Polar area, of which the industry of Dr. Petermann has collected a vast body of indisputable evidence; and for this discussion we would refer such of our readers as are specially interested in the question to the last part of the "Proceedings of the Royal Geographical Society." But as Dr. Carpenter has now shown a capacity to deal not merely with Physiological but with Physical questions, in a manner which has obtained the approval of some of the ablest physicists of our time, we hope that he will not again be accused (as he was by some of those who opposed his views on their first promulgation) of venturing beyond his depth when he began to reason on these subjects, and of advancing doctrines which his own observations refuted. The exclusive doctrine of the thermal action of the Gulf Stream advocated by Mr. Croll, rests, as Dr. Carpenter has shown, upon so insecure a basis, that a very large body of careful observations must be collected before any reliable data can be obtained as to the heat it actually carries forth from the Gulf of Mexico. And how much of this heat is dissipated by evaporation, as well as by radiation, before one-half of the Stream reaches the banks of Newfoundland (the other half having turned round the Azores to re-enter the Equatorial current), is a question which there are as yet no adequate data for determining. On the other hand, in his conclusion that a great body of Ocean water slowly moving northwards, so as to carry with it a considerable excess of temperature even to the depth of 500 or 600 fathoms, must exert a much greater heating power than the thinned-out edge of the Gulf Stream, Dr. Carpenter seems to us to have both scientific probability and common sense on his side.

IRON AND STEEL NOTES.

The largest scales factory in the world is that of the Messrs. Fairbanks at St. Johnsbury, Vt. Established in 1830, and then employing only a few hands, their factory now covers acres of ground and gives constant employment to over 500 men.

Iron Paper.—In the Great Exhibition of 1851 an American specimen of iron paper was first exhibited. A lively competition in iron rolling ensued among British iron manufacturers, excited by the above challenge from America, as to the thinness to which steel could be rolled cold. Mr. Gillott rolled sheets the average thickness of which was the 1800th part of an inch. In other words, 1,800 sheets piled upon each other would collectively measure an inch in thickness, whilst the thinnest tissue paper to be purchased in the stationers' shops measured 1,200th part of an inch.

These very thin iron sheets are perfectly smooth and easy to write on, although porous when held up to a good light. It may not be out of place, considering the great interest that is taken by those connected with that great branch of industry the iron trade, to give a few curious particulars as to the extent iron can be welded, and the thin

sheets that can be rolled out. Brother Jonathan little thought what a hubbub would be created in the old country when from Pittsburg he sent that wonderful letter, written on a sheet made from iron, which took no less than 1,000 sheets to make 1 in. in thickness, the dimensions being 8 in. by $5\frac{1}{2}$ in., or a surface of 44 in., and weighing 69 grains. The fact had no sooner made its appearance in print than Britain's sons began to work, and soon we heard of a sheet containing the same number of surface inches, but weighing only 4 grains, had been made at the Marshfield Iron Works, Llanelly, Carmarthenshire, being exactly one-third less in weight. But soon the Welsh leek had to give way to the rose of England, for Staffordshire was anxious to take its wonted lead. The Hope Ironworks succeeded in making a sheet of 11 surface in., weighing but 89 grains, which, reduced to the American and Welsh standard of 44 in., gives about 33 grains; Messrs. R. Williams and Co., 69 in., 49 grains; reduced to the same standard, about 31 grains. For a time Staffordshire wears the belt, but Wales becomes very restless, and is anxious for the honor of St. David; so further attempts must be made. Marshfield comes again into the field. They succeed in making one sheet, 8 in. by $5\frac{1}{2}$ in., or a surface of 44 in., of the astounding weight of $23\frac{1}{2}$ grains only, which required no less than 2,583 sheets to make 1 in. in thickness; another sheet, 8 in. by 6 in., or 48 surface inches, weighed 25 grains, but brought to the standard of 44 in. gives but 23 grains, and requires 2,950 sheets to make 1 in. in thickness. The Pontardawe Tinworks next come into the field with a sheet $14\frac{3}{4}$ by 7 5-16ths, or a surface of 115.17 in., weighing 60 grains: but being reduced to 44 in. is $24\frac{1}{2}$ grains— a trifle heavier than the Marshfield, but Pontardawe claims 3,799 sheets to make 1 in. in thickness.

We now come to the climax. The mill-manager of Messrs. W. Hallam and Co., of the Upper Forest Tin Works, near Swansea, has succeeded in making a sheet of the finest appearance and thinnest that has ever yet been seen by mortal eye. The iron from which the sheet was rolled was made on the premises. It was worked in a finery with charcoal and the usual blast; afterwards taken to the hammer, to be formed into a regular flat-bottom; from thence conveyed to the balling-furnace and when sufficiently heated taken to the rolls' lengthened, and cut by shears into proper lengths. piled up, and transferred to the balling-furnace again; when heated it was passed through the rolls, back again into the balling-furnace, and when duly brought to the proper pitch was taken to the rolls, and made into a thorough good bar. Such is the history in connection with the forge department. It was then taken to the tin-mills, and rolled till it was supposed to be thinner than 23 grains, afterward passed through the cold rolls to give it the necessary polish, and now it stands on record as the thinnest sheet of iron ever rolled, The sheet in question is 10 in. by $5\frac{1}{2}$ in., or 55 in. in surface, and weighs but 20 grains, which being brought to the standard of 8 in. by $5\frac{1}{2}$ in., or 44 surface inches, is but 16 grains, or 30 per cent. less than any previous effort, and requires at least 4,800 to make 1 in. in thickness.—*Mining Journal.*

Phosphorus in Steel.—M. Gruner, Professor of Metallurgy at the School of Mines at Paris, has published in the "Annales des Mines," 1870, xvii., p. 346, a paper on the Mechanical Properties of Steel containing Phosphorus. Premising by stating that in a previous memoir on the Heaton process (Examen du Procédé Heaton, Paris, 1869) he had sought to prove (1) when pig iron containing phosphorus, but poor in silicon, is refined with nitrate of soda, that although the greater part of the phosphorus is eliminated, it still retains two or three thousandth parts of this substance, if the amount of nitrate employed be below 13 to 15 per cent. of the weight of the pig iron. (2.) That these two or three thousandths of phosphorus will render the product more or less brittle. (3.) That the presence of the phosphorus increases up to a certain point of resistance to fracture, provided it be tested by a slow and gradually applied force. 4. That, as before shown by Dr. Wedding, steel not containing more than 0.005 of phosphorus may be easily worked cold; goes on at length into the consideration of the mechanical properties of certain samples of steel, the testing of which had been conducted by Mr. Fairbairn, whose results are given in a comprehensive table, and, as the result of this inquiry, Professor Gruner arrives at the following conclusions: 1. That phosphorus, when present in steel in the proportion of from 0.002 to 0.003, renders it rigid and elastic; increases its elastic tension and resistance to fracture, without altering its hardness; but that such steel, even if it contains but little carbon, wants "body," and is brittle, without being at the same time hard. 2. In order to show this want of "body," the tests of simple traction and transverse pressure are not sufficient; it requires testing by blows or shocks. 3. That soft Bessemer steel, produced from hematite, at Barrow, possesses less tenacity and elasticity, and is more brittle than the soft or extra soft Sheffield crucible steels; and 4. That steels containing phosphorus are deficient in "body," and that it is at present premature, either to consider the Heaton process as a great improvement in steel making, or that the steel prepared by this process can be favorably compared with the usual Sheffield product.

Utilization of Slag.—Although numerous attempts have been made to utilize the slags from blast furnaces, this problem has not as yet been solved practically on the large scale; if, however, we can place credit in the statements of M. Kennis, success has attended his efforts, made in Belgium, to prepare from the slag an artificial stone, said to be now used on the large scale for paving the streets of Brussels. The *modus operandi* is simple enough, as it merely consists of allowing the cinder to run direct from the furnace into a large pit, sufficiently capacious to hold the entire daily production; when the pit is quite full, the cooling of the mass is still further retarded by covering over the surface of the slag with earth. The effect of this slow cooling of so large a mass of slag, is to convert the whole into a solid slagstone, possessing, when cold, a chrystalline or somewhat porphyritic texture, with a density of about 2.77, which can be used for making paving-stones, which are stated to wear well, not to become slippery by use, and to be more economical, as they cost 20 per cent. less than the ordinary stone used for pavement in Brussels.

In some iron works, where space is an object, it is important to diminish as much as possible the room taken up by the hot slag in cooling, before it can be carted away. For this purpose, at the Prieure Ironworks, at Longwy, Moselle, a com-

pact hydraulic arrangement has been constructed by Baron D'Adelswaerd, by which the molten slag, previously run into iron wagons, is lowered bodily, wagon and all, into a tank of water, so as to be cooled at once; by which means the space required for cooling the slag is said to be diminished from 420 to 52 sq. metres, and only 6 men with 2 horses are now required for clearing away the slag from each furnace, instead of 4 men with 3 horses, thereby effecting a saving of 31 francs daily per furnace.—*Journal of Iron and Steel Institute.*

RAILWAY NOTES.

The Direct Indus Valley Railway.—There is a diversity of opinion on the present and future prospects of this important line of railway. The "Globe" thus remarks on the subject:—We fear a grievous mistake was committed in carrying the Sindh Railway from Karachi to Kotri, instead of about seventy-five miles more to the north, to Sehwan. It is true that opposite Kotri, on the left bank of the Indus, and at 3½ miles distance from it is Hyderabad, the capital of Lower Sindh, a town of perhaps 25,000 inhabitants. But between Kotri and this town flows the Indus, which is at all times at that point a considerable river, but from July to the end of October a deep, rapid, and truly formidable flood. The expense of bridging the river at Kotri, and the possibility of the bridge being swept away, are objections of themselves sufficient to condemn the scheme, too hastily carried out, of uniting Karachi and Kotri by rail.

But if Mr. Hardy Wells, in his pamphlet called "India and Russia," is correct in his calculations, the line from Karachi by Sehwan, Larkhana, and Shikarpur, to Dera Ghazi Khan and Multan, is only 493 miles, while that by Kotri and Bhawalpur to Multan is 622 miles. If that be so, a railway on the right bank of the Indus to Multan from the sea might be made 129 miles shorter, and at £11,000 a mile, £1,429,000 cheaper than one on the left bank of the river to that city. Even this is far from all that can be said in favor of the right bank. The Indus at Kotri and Rohri is of prodigious breadth, depth, and swiftness. At Sehwan it is not so broad, but immensely deep, and at not one of the three places is the idea of bridging it to be entertained for a moment. But at Dera Ghazi Khan, which is 200 miles above Rohri in a direct line, and very much more by the river, the stream is not so formidable. This consideration, however, is as nothing compared with the fact that Larkhana, Shikarpur, and Dera Ghazi Khan are the three enterepots where the traffic from Afghanistan and Central Asia debouches, and they are all three on the right bank of the Indus. A railway, therefore, on the right bank would receive all this traffic, while one on the left bank would be cut off from it by an almost impassable river. That traffic has from time immemorial descended the valley between the Hala Mountains and the Indus, and trade sticks to its old routes. We doubt whether, even if the river were bridged, the Afghan traders would cross to the other side.

Lastly, there is the question of a war on the north-western frontier of India. Were Herat and Kandahar in the hands of the Russians, or in the possession of Yakub Khan in alliance with Russia, an event which may be announced at any moment, with the pleasing accompaniment of plundering raids on our frontier villages, a railway on the right bank of the Indus, as designed and recommended by Mr. Wells, would be of incalculably greater advantage to us for military purposes than one on the left bank. In the one case we might carry a short line to the mouth of the Bolan and Gandava Passes and to that opposite Shekh-i-Sarwar, close to Dera Ghazi Khan; in the other case we should have to cross a great river and forward our troops and stores by long and weary marches to the scene of action. There is also the fact that on the right bank the territory is our own; on the left, for a considerable distance, it belongs to Bhawalpur. But we do not attach much importance to this point.

But on the whole, it seems to us in the highest degree desirable that the Secretary of State for India should at once sanction a direct line of railway from Karachi to Larkhana, Shikarpur, Mithaulcut, and Dera Ghazi Khan, and that to save expense it should be throughout constructed on the new principle of narrow gauge and light rails. We are convinced that no time is to be lost, and that if we do not wish to be out-generalled by the march of events the works should be commenced at once. That it would be a paying as well as politically valuable line there can be no doubt, and we only regret that it was not long ago sanctioned and commenced.

Electric Railway Signals.—The New York "Tribune" gives a description of a railroad signal system invented by Thomas S. Hall, which, it says, has been tested on the Morris and Essex and the New York and New Haven roads:—"The system includes a series of devices by which, through the agency of electro-magnetism, an alarm signal is displayed and a bell rung whenever a switch-rail is out of place, a draw-bridge open, or a train is approaching a road-crossing. In each instance the operation of the signal is entirely automatic. Inclosed in a stout box at the point of application to the main line are several metallic rods connected by electrical conductors with a galvanic battery capable of yielding constant currents whenever the circuit is completed. The conducting wires are carefully insulated, and terminate at the signal station in the cores of two electric-magnets An armature directly above the electro-magnets acts by means of a lever upon a signal staff and the clapper of an alarm bell. So delicate is the adjustment of the metallic rods at the point of application, that the displacement of a rail on either side of the main line, or the withdrawal of a bolt that secures a drawbridge, or the passage of a train over the track, is sufficient to connect the poles of the battery and to complete the circuit. The flow of the current vitalizes the electro-magnets at the signal-station and the armature moves, resulting in the ringing of a bell and the raising of a colored signal. The bell continues to ring and the signal is uplifted until the electric current has been broken by the readjustment of the rail or the replacement of the bolt of the drawbridge. The electro-magnet may be acted upon at a distance of a few yards or of many miles, so that an alarm may be sounded at any distance from the point of danger, and signals may be displayed in either direction at such distances as to allow the stoppage of a train. The apparatus is the same in principle for every application, although there are various devices for operating the signals. The

applications are four in number—to switches, drawbridges, and highway-crossings, and in what is known as the "block" system. By an attachment to switch-rails, double warning is given, to the eye of the engineer and to the ear of the switch-tender, whenever a switch is opened on the main line so as to endanger passing trains. In the case of drawbridges, alarm signals continue in operation until the draw is closed and the bolt which secures it is replaced. By the block system, the wheels of a passing train come in contact with a series of delicate levers, at intervals of two miles on the main line, each of which closes an electric circuit, by means of which a signal is brought into sight two miles in advance of the train. At the same time, the pressure of the wheels upon another lever breaks the circuit, and the signal at the station which the train is passing falls by its own weight. This system by which a train registers its position two miles in either direction, is designed to prevent collisions on single or double tracks. In like manner, when a train is a mile and a half distant from a highway crossing, a bell may be rung and a signal displayed, by which teamsters will be given timely warning of the near approach of the train."

NARROW-GAUGE ROADS.—The British Government appointed, in 1869, a Commission to consider what gauge should be adopted for "the Indus Valley and other projected Railways." After more than a year of careful investigation, this Commission has reported, and within the last month the Indian authorities have decided on the width of 3 ft. 3 in. for all State lines. This action extends the narrow-gauge system to lines nearly 10,000 miles in aggregate length; intended to give all needed facilities to fast areas of territory and immense populations. It is the most important indorsement the narrow-gauge system has yet received, and will greatly influence decisions as to the width of gauge, the world over.

RAILWAYS IN TIME OF WAR.—Captain Tyler has written an interesting letter on the subject of the military use of railways, observing, that in future the success or otherwise of combined military and naval expeditions from this country may, in great measure, depend upon the promptitude with which railway communication can be established. He urges the desirability of a proportion of the officers and men of our Corps of Royal Engineers being specially trained and practised in such duties. The subject is engaging the consideration of the Royal Engineers at the War Office.

RAILWAY CARRIAGES.—The earliest railway carriages, those made in 1830 for the Liverpool and Manchester Railway, were mere open boxes, hardly as good as our present cattle trucks. They had 4 wheels, no springs, and no roofs. There were no compartments at first, and all the carriages were of the same class. In the next year Joseph Knight added springs to the carriages, and improved their construction considerably; he also made the periphery, or, as it is commonly called, the "tread" of the wheels conical, instead of flat, thus enabling the cars to round corners more easily. The greater improvements have since been made. Long before this, it is true, in 1825, W. H. James obtained a patent for a wheel of which the tire was made in "steps,"—that is, it was of different diameters at different parts. The object was of course the same as in Knight's invention. In 1839, 3 classes of carriages were used, as now, but all much inferior to those in use at present. The next improvement was to divide each carriage into compartments, which was done by Mr. Hanson, who built them of iron. Each compartment had one seat which was movable, so that the passengers always sat with their faces towards the engine. Footboards and rests for the back were provided, but they do not seem to have been very comfortable. As at present built, wood, leather, and metal are generally used in passenger carriages, wood and iron for wagons and trucks.

For the under frames of carriages English oak has been found to be the best material, as well as for the pillars of carriages, and the under and upper frames of wagons. Ash has been found most suited for the construction of carriage bodies and roof-ribs, and deal for the lining, roofing, and flooring of both carriages and wagons.

Iron has been used both for trucks and carriages, corrugated sheet iron, with some success, especially for the panelling of carriages. Wrought iron, if the carriages are strong enough to resist breaking in case of accident, is too heavy, and in any case there would be many dangers in its use. As has been observed, if such a carriage did collapse, the passengers would be crushed within it, and the unriveting of the parts of the carriage in order to extricate them would be a fearful process.

With regard to the other parts of the carriages, the great patent for a buffer is dated 1835, and is for "improvements in the buffing apparatus." The buffer is of much the usual description. As regards brakes, there is even still abundant room for improvement.

Blocks to be pressed against and sledges to be passed under the wheels; cylinders filled with liquid in which pistons were to be worked to and fro; the resistance of the air, and the action of magnetic attraction, have all been enlisted into the service with varying success; but some means of stopping a train without either wearing the wheel, or throwing it off the rail, have yet to be found.

RAILWAYS IN TURKEY.—The construction of a network of railways is an enterprise of no inconsiderable importance and difficulty in a country the interior of which is comparatively so little known, and where the means of communication are in a most primitive condition. In the first place, there being no reliable map of the country, considerable time has been expended in making the necessary surveys, to fix upon the best line for the railway. The total length of the lines to be constructed is about 2,400 kilometres (1,500 English miles), the general route of which, with the exception of a short section in Bosnia, has been approved of by the Porte. About 750 miles of the most important lines have already been surveyed in detail, and the surveys for the remaining portion are being pushed forward with the greatest alacrity. M. Vitali, the representative of a firm of contractors, has undertaken the construction of the line from Constantinople to Adrianople, a distance of 290 kilometres (181 English miles), and of another from Dedeagh to Adrianople, 140 kilometres (87 English miles), in length; the former of which is to be completed in 2 years, and the second in a year. In this man-

ner, the second city in importance in the empire will be placed in communication with the Archipelago by the 1st January, 1872, and by 1st January, 1873, it will be united with the capital. An Italian firm of contractors have undertaken the construction of the railway from Uskub to Salonica, following the valley of the Vadar, which will open out a highway for the carriage of the products of Macedonia to the Mediterranean. This line will be about 248 kilometres (150 English miles) in length, part of which is to be opened by the end of the present year, and the remainder by the end of June, 1872. The line from Adrianople to Sarimbey via Philippolis, which is an extension of the line from Constantinople to Adrianople towards Servia, is already commenced, and is to be opened about the same time as the latter line. It will be about 300 kilometres (187 English miles) in length. The junction of the Ottoman railways with those of Austria, by means of the line from Novia to Banjaluka, a distance of 110 kilometres (69 English miles), is in construction, and will shortly be completed. In this manner there are already 1,080 kilogrammes (675 English miles) in construction, part of which will be opened this year, and the remainder to be completed by the end of 1872. A short section, of 17 kilometres (10 English miles) in length, following the shore of the sea of Marmora, from the Seven Towers to Kutchuk-Tchekmedje, and forming the first link of the line to Adrianople), is just finished and opened for traffic. The station at the Seven Towers is only a temporary terminus for the line, and the railway company, seeing that but little traffic could be expected from a line ending in one of the suburbs of Constantinople, and at a considerable distance from the centre, with no communication with the ports, or the quarters of Pera and Galata, have come to a decision to extend the line as soon as possible, and have laid before the Government a project of a line traversing the city, with the terminus near the new bridge. The Company are about to give an order for 100 locomotives and 1,000 wagons.

The Fastest Time in the World —The London "Morning News," in an article entitled, The Fastest Time in the World, says: "The new express train from Plymouth to London, will probably be the fastest train in the world in the part of its journey which lies over the Bristol and Exeter and Great Western Railways. Leaving Exeter at 10.30, it is timed to reach Padington at 2.45, including a stoppage of five minutes at Bristol, and the inevitable and vexatious ten minutes at Swindon, the journey of 194 miles will occupy 4¼ hours." This is first-rate railroad time, but it yet remains to be seen whether or not it is surpassed in the United States. If we take off the time put down for stoppages in this case, the running is reduced to four hours, which gives a fraction less than fifty miles per hour. This time, if we are not mistaken, has frequently been made on the Hudson River road, and in exceptional cases a speed of sixty miles an hour has been made for some considerable distance. The work, however, to be performed under the schedule between Plymouth and London, is a good approximation to the maximum capacity of the best English railway management, but it will scarcely compare with the best time made between New York and Chicago, over the New Jersey, the Trenton, and the Pennsylvania roads, the "junction road" being used as a connecting link.

From New York to Chicago the distance by this route is 913 miles—say New York to Philadelphia, 90; Philadelphia to Pittsburg, 356; Pittsburg to Chicago, 468. The best schedule time that we are apprised of on this route was that under which the trains were run during a part of 1870. This was going east from Chicago to New York in 27 hours. On this schedule there were 34 stops, 2 of which were for meals, and which we put down at 20 min. each, thus reducing the *running* time to 26 hours and 20 min. We average the 32 remaining stops at 2 min. each, which we presume is altogether inside of the time thus lost, and we have then to deduct from the running time of this train 64 min., which brings it down to 25 hours and 18 min. We then deduct 50 min. for difference in time between these two points, and we have the exact running time under the schedule of 1870, fixed at 24 hours and 28 min., which is a trifle over 30 miles an hour, when it is considered that many large towns are passed through on this trip, including Philadelphia, Harrisburg, and Pittsburg, and that the line is nearly 5 times the length of that between Plymouth and London, we submit that our English cousins have not yet earned the distinction of making "the fastest time in the world."

We are quite willing to concede that, in the general, the time made on the principal roads in England is better than in America. There are good reasons why it should be so. The cost of building and maintaining railroads on the other side of the Atlantic is much less than here, and the companies owning them there can afford to police the route by the employment of such numbers of flagmen and guards as is quite out of the question in the United States under existing circumstances. But we are yet in infancy as to the matter of rail-roading. Wonderful as has been our progress, and grand as are the accomplishments, we have yet much to learn, and the most important lesson is that which will convince managers that they owe a more liberal expenditure of earnings for the accommodation and safety of the travelling public, and a less munificent distribution of funds to shareholders in the shape of dividends. But as to the question of fast time, it is for practical railroad men in our country to determine on the claim set up by our London contemporary. It must, of course, be settled according to the view we have taken; that is to say, by a comparison of the aggregate length of line run over.

ORDNANCE AND NAVAL NOTES.

There are several plans and specifications for iron coasting steamers now being estimated upon in this city, and we are informed by prominent builders that there seems to be a prospect for some ship-building business this fall. One large composite side-wheel steamer, for a China house, is now being laid down, and it is said that the probabilities are that several will be built at no distant day. We hear also that a few medium-sized sailing ships will be built in Eastern yards this season, but these are only to replace vessels lost or destroyed. The building of coasting craft has been quite brisk of late, and many fine vessels have been added to our tonnage list. A new problem will be presented

relating to ship-building, especially on the lakes, when the Treaty of Washington has its due effect, and if Congress does not interfere, our inland ship-builders will see their business sacrificed, as has been that of their brethren on the sea-board. A great responsibility rests on Congress. The Nation is humbled to the dust, and its shipping will be driven from the lakes as it has been from the ocean, if help is not given us from Washington. Our Congressmen have too long been tolerated in making buncombe speeches, and have reached a point when the concerted voice of the people will cry out against windy debates, which result in neither credit to them or good to the nation.—*Nautical Gazette.*

Launch of the Steam Yacht Day Dream.—The Continental Iron Works, Greenpoint, L. I., launched, on Thursday, at 12.35 P. M., the composite screw steam yacht Day Dream, built by Thomas F. Rowland for W. H. Aspinwall. The day was fine, and a large number of ladies and gentlemen assembled to witness the launch, which passed off to the entire satisfaction of all present. The Day Dream, probably, marks a new era in our ship-building annals, and from her advent we may date the beginning of a demand upon our ship-builders for composite vessels. She was modelled by La. Smith, and exhibits a marked symmetry of lines, and beautiful curves, and in all probability will develop a high rate of speed. Her frame is of $2\frac{1}{2}$ in. angle iron, placed 21 in. from centre to centre, over which are placed diagonal straps $3\frac{1}{2}$ in. in width by $\frac{3}{16}$ in. in thickness, extending from the garboard to the wale-strake. The planking is of yellow pine, $1\frac{3}{4}$ in. in thickness, sheathed with 1 in. white cedar. Three iron water-tight bulkheads are fitted in the vessel—two completely enclosing the boiler and engine space, and the other placed forward, so that, in event of damage to the bow, the fore compartment would prevent the vessel from sinking. The Day Dream measures 105 ft. on the water-line, 120 ft. on deck, and has 7 ft. depth of hold, and when in trim will draw 5.6 ft. Her motive power consists of a pair of Reynolds vertical direct-acting condensing engines, with 14-in. cylinders and 14-in. stroke of piston, The propeller screw is 7 ft. in diameter, with 10.6 ft. pitch. The engines, with a pressure of 80 lbs. of steam, are calculated to make 135 revolutions per minute, giving to the vessel a speed of 13.5 knots per hour, slip off. She has one return tubular boiler, with 40 sq. ft. of grate surface and 1,200 sq ft. of heating surface. She is schooner-rigged and sparred with much rake. The area of her canvas is as follows: jib, 880 sq. yards; foresail, 950 sq yards; and mainsail, 1,400 sq. yards. See will carry no topsails or squaresails. Her standing rigging is of the best wire-rope and gives her a light airy look. There is an iron keel-strap, which runs from the upper end of the stem, under the keel and up to the upper end of the stern-post, adding very materially to the strength of the vessel. The bowsprit is moulded into the hull and gives her a neat finish. The accomodations are the work of John E. Hoffmire and are contained in a trunk cabin, the grand saloon being forward of the machinery, which is amidships, and the after space being devoted to the kitchen, pantries, store-room, crew-quarters, etc. The saloon companion-ways are a trifle forward of amidships, and give a spacious entrance to it. The sleeping accommodations are temporary, being removed in the morning, leaving the space clear during the day. They are easily put up when required. She will be handsomely decorated *á la arabesque*, and while no pains will be spared to make her cosy, comfortable, and even luxuriant, yet no foolish, tawdry decorations will be put on her. She is intended for a gentleman's pleasure yacht, and will be the finest steamer yacht in American waters.—*Nautical Gazette.*

The Ship New Era.—The ship New Era, built in East Boston, 1870, is the first vessel of any considerable tonnage intended for the foreign trade, whose owners have dared, in their consciousness of right, to ignore the classification of British and French Lloyds, relying upon home surveys, which have resulted in the ship being written for a round voyage of over 12 months for $5\frac{1}{2}$ per cent. One of the specialties of this vessel consists in having the entire frame, together with breast hooks and knees, of grain-grown timber, bevelled to the required angle and bent to the required form by machinery, making a frame of 3 instead of 13 *pieces* of grain-cut timbers in short lengths. These peculiarities of construction which have thus engendered confidence in the United States, and secured this low rate of insurance, are not known, and therefore not appreciated by the Lloyds Committee of England and France.

The history of ship-building in the past furnishes no evidence that the most important element of strength in timber has before been utilized in the framing of large vessels. When elasticity shall be regarded as a positive, and flexibility as a negative element of strength, in the frames of ships, then will the science of mechanical engineering be fully appreciated in nautical construction. Elasticity is that spring back, recoiling quality, inherited in woody fibre, and the index of strength. It is an indestructible property, while the fibrous vibrations remain undisturbed, by severance or rot. The New Era's bulk has been determined to be 1,146 tons, 1,026 of which is under deck; the carrying capacity for cargo, by displacement, is 150 per cent. of the gross tonnage, within a draught of 20 ft. water. The structural distribution of materials peculiar to this vessel may be thus given: The room and space is 21 in. with single timbered frames, sided 10 in., extending from keel to rail in one length; the two timbers on opposite sides, together with the floor timber, make the frame, to which is attached a beam for each of the two decks, with two hanging knees at each end of each beam, placed on the sides of the frame timbers and beams, belted horizontally; this renders lodge and bosom knees an incumbrance, rather than a benefit. By this arrangement the deck beams are all in place, as also the knees, both of which are fastened when the frames are raised, and both may be regulated by the water ways, as the raising of frame progresses, which was the case in the New Era's construction.

Having beams to every frame rendered ledges and carlins unnecessary, and the stanchions, both in the hold and between decks, were placed between girders, side strake and keelson. The single frame timbers dispenses with frame bolts, which shut out so large a proportion of the through fastenings, consequently there are more through tree-nails than is usual in vessels of equal tonnage. In the distribution of sail, the centre of effort is within $2\frac{1}{2}$ ft. of the centre of length on load line, very much farther aft than is usual, which dispenses with the steving bowsprit, usually stepped between

a pair of bitts. The jib-boom is conveniently arranged to be run in and out, and is stepped by a fid bolt at the knight heads. The bow chocks are bent, and extend to cap through which jib-boom passes ; the usual cutwater cheets and head rail, are dispensed with, a curved pair of breakwaters supply their place—the stern is also supplied with characteristic ornaments, without the sweeping taffrail. Such are the advantages of this mode of construction, that, with the same internal capacity, a vessel can be built stronger, lighter, of greater speed, more durable, less draught of water, and at less cost, by this than by any other mode of construction, whether in wood or iron.—*Nautical Gazette.*

ENGINEERING STRUCTURES.

The Darien Survey.—We extract from a late copy of the "New York Herald," the following in regard to the returning Darien expedition :

What fresh intelligence she may bring respecting the character of the "divide" already thoroughly explored it is impossible to say, but it is hardly probable that any lower elevation than that previously announced has been discovered. And even though a depression be found so low as 400 ft. it would not alter the conclusion already arrived at as to the impracticability of the Tuyra-Atrato route. The mountainous character of the country on the Pacific side precludes all idea of an interoceanic canal within miles on either side of the Tuyra River. Precipitous hills present the most insuperable barriers all the way from Pinogana to the Cue and thence to the "divide," while the river itself is so tortuous in its course as to shut out all hopes of navigation. Yet a great work has nevertheless been accomplished, and the survey of this supposed route must ever hold a prominent place in the important enterprise of the age. That substantial and reliable facts heretofore only surmised have been established is beyond all question, and any authentic information relative to the nature of this particular portion of the isthmus must be credited to this undertaking. Notwithstanding all the voluminous reports that have been published regarding the Tuyra River and its surroundings, excluding entirely the imaginative sketches of wordy adventurers, the fact remains that prior to the advent of this expedition upon the isthmus little or nothing was known about the route surveyed. Had any canal route existed in this direction it would most assuredly have been discovered by this undertaking, and not previous to its coming. Better organized and more thoroughly equipped than any previous expedition, that which has now completed its labors may well be congratulated upon its results, having done much to set at rest the various theories and speculations that have for years been fruitlessly indulged in. From the commander down to the least important participant in the extensive operations there have been displayed a zeal and a perseverance rarely met with under such adverse circumstances. And although the anticipations relative to the route referred to have not been realized, although the character of the country proved vastly different to that which scanty information led the commander and his officers to expect, almost equal credit is due the expedition as if a first-class route had been discovered, since the amount of labor and anxiety involved were in both cases the same. So much for the Tuyra-Atrato route. What recommendations Commander Selfridge will make upon his return it is impossible to say until the reports of the surveying party on the Atlantic side shall have been handed in. It is reasonable to surmise, nevertheless, that the tunnelling of the summit dividing the Cue from the Paranchita River will not be included. Indeed, there is scarcely a doubt but that, everything duly considered, this route will be pronounced impracticable. Not so, however, the route from the Pacific to the Atrato by way of the Napipi, of which full details have already been given. Great confidence is entertained in regard to the success of this line. It is not by any means claimed as an original discovery, though it is very doubtful whether any regular surveying party ever drew a complete line across to the Atrato River ; but it is contended, and not without reason, that no previous expedition ever established the same facts relative to its feasibility for an interoceanic canal. The only point yet undetermined in regard to it is as to the character of the Atrato River at the confluence of the Napipi. It has been thoroughly examined by a party from the Guard, but the result will not be known until the vessel arrives at Aspinwall. The line of the proposed canal is 31 miles, the dividing ridge of 612 ft. rising above a quarter of a mile from the Pacific shore. As previously mentioned, lockage and tunnelling would be necessary. The supply of water comes from the Dogadow River and other tributaries of the Napipi, the volume being over 2½ million gallons per hour. It is proposed to have 9 locks from the Atrato to the Dogadow, or one at every elevation of 10 ft., which would make them about 2 miles apart. From the Dogadow a cut of over 100 ft. is suggested, after which comes a tunnel of 3½ miles through the "divide." Vessels would then descend to the Pacific by means of 13 locks. The entire distance from ocean to ocean would be about 150 miles. This, in brief, is the so-called Napipi route from Cuxica Bay, surveyed in April last. It certainly presents much more favorable features for a canal than the Tuyra-Atrato route. But whether a deep cut even through such a formidable obstacle as 612 ft. of rock would not be preferable to tunnelling is a question for consideration. Beyond doubt there are many difficulties presented, but that they could readily be overcome by the engineering skill of the present day is equally certain. Having already given full descriptions of both routes and their prominent features, it will be unnecessary to recapitulate. To all it must be evident that the expedition has accomplished a great deal. Two complete lines have been drawn from ocean to ocean, furnishing the most satisfactory and reliable information as to the surroundings of the portions surveyed. Should neither of the lines be declared feasible, though the Napipi route is very likely to be, the field of future labors has, at all events, been considerably diminished. Great credit is due the expedition for the unwavering pertinacity which throughout characterized its action. From the day on which the first tree fell beneath the blades of the macheteros until the operations on the Pacific side were completed, nothing could surpass the order and cheerfulness of every one engaged in the operations ; and when the labors were fairly commenced, and when the sufferings incidental to the exploration

caused many to think of the comforts they had left behind, not a word of complaint was uttered, for the hope that their labors would be rewarded by the discovery of the great highway from the Atlantic to the Pacific encouraged the surveyors to the last. Whether in the dense jungle, cutting a path at the rate of a mile a day, or plodding through the swamps in canoes, the best of spirits were maintained. More voracious insects never commenced a siege against defenceless mortals, and at times both men and officers presented a sorry sight. There was fever in the camps, and the bravest of the men were prostrated for days, but the unremitting care and attention of the medical officer soon dispelled all fears, so that when sickness did come it was thought lightly of. With the exception of one machetero, a native of Carthegena, who imbibed too freely, no deaths have occurred in connection with the expedition. To this gratifying circumstance may be attributed the splendid discipline, the prompt supplies of substantial rations and suitable appurtenances and the regularity with which the admirable arrangements were carried out.

Steam on the Canals.—At a meeting of the Commission appointed by Act, Chap. 868, Laws of 1871—"An act to foster and develop the internal commerce of the State by inviting and rewarding the practical and profitable introduction upon the canals of steam, caloric, electricity, or any motor other than animal power, for the propulsion of boats," held at the office of the State Engineer and Surveyor, July 10, 1871, it was

Resolved, that the Governor be requested to fill the vacancy in the Commission appointed by Act, Chap. 868, Laws of 1871, caused by the declination of the Hon. Horatio Seymour.

Resolved, That for the purpose of carrying out the intent of the law, this Commission will require, among the tests to be made, that the several competitors shall make not less than three round trips, from New York and Buffalo or Oswego, each boat to be loaded with not less than 200 tons of cargo each way, the trips to be commenced as soon as any party is ready, and all completed in the least practicable time. For the purpose of determining the time consumed by each and all the trips, the clearance must show the day of the month and the time of day that the boat passes each Collector's office ; certified copies thereof to be furnished the Commission. In order to obtain information in regard to the practical working of the several devices in competition, as soon as practicable the Engineer of the Commission, Mr. David M. Greene, of Troy, will inspect the same from time to time, as in his judgment may be necessary, and report the facts obtained to this Commission,

Resolved, That competitors are hereby notified that for the purpose for carrying out the intent of the law, though it is desirable that the three consecutive round trips from Buffalo or Oswego to New York be made at the earliest time practicable, that the whole of the year 1872 will be allowed to such persons as may desire so much time, and that the awards will not be made until the close of navigation in that year.

Resolved, That a copy of the foregoing resolution and of the law, be furnished by the Secretary to all persons who may desire to compete under it, and that on Monday, the 14th day of August, 1871, at 3 o'clock P. M., the Commission will meet at the office of the Canal Commissioner in Syracuse for the purpose of transacting any business that may properly come before them.

Any person desiring to communicate with this Commission or with the Engineer, Mr. Greene, will address the Secretary, Mr. Henry A. Petrie, at the office of the State Engineer, Albany. The Commission adjourned to meet at Syracuse, Monday, August 14, 1871.

The Great New York City Railway Depot.—We note the completion of the new Union Depot which, during the past year or two, has been in process of construction. It is situated on Fourth avenue and Forty-second street, and is designed for the use of the New York and Harlem, New York Central, including the Hudson River Division, and the New York and New Haven Railways. It is the terminus of more than 1,000 miles of railway lines; has more than 2 acres of glass set in the iron sashes of its roof ; and is 695 ft. long, 240 wide, and 109 in height, measuring from the ground floor to the centre of the roof. It covers nearly 5 acres of land, and contains in all about 100 rooms, which will be heated by steam, lighted with gas, and supplied with water. The weight of the roof is stated at 23 lbs. per superficial in., and due provision is made for the expansion and contraction consequent upon changes of temperature. One curious but perfectly intelligible result of such variations in heat and cold is expected in the rising and falling of the roof to the extent of 3 in. at different seasons. The walls are of granite and bluestone, the former from Portland, Me., and the latter from East River quarries.

The outbuildings adjunctive to the depot will cover 6 or 7 acres or thereabouts, some of them being of 2 stories, with the lofts adapted to storage purposes. The tracks in the immediate vicinity of the depot will be fitted with automatic electric signals to instance the approach of the trains, their passage through the adjacent tunnel, and to guard generally against danger of accident. Such, in brief, are the distinctive features of one of the largest, if not the very largest, railway depots in the world, a structure which, in its size and completeness, may serve as an index to the colossal growth of the railroad interests of the country at the present time.—*Am. Artisan.*

NEW BOOKS.

The Journal of the Iron and Steel Institute, No. 2. For sale by Van Nostrand.

This journal well sustains the promise held out by its first number. The part now before us contains a continuation of Mr. I. Lowthian Bell's valuable researches on the "Chemical Phenomena of Iron Smelting ;" an account of the meeting of the Iron and Steel Institute held in London in March last, together with the address of the President, Mr. Henry Bessemer, and the various reports and papers read on that occasion ; and finally Mr. David Forbes's excellent quarterly report on the progress of iron and steel industries in foreign countries, and some interesting notes on the British iron and steel trades.

Modern Artillery. By Lieut.-Colonel Owen, B. A. London : John Murray.

This work deals with an increasingly interest-

ing subject—modern artillery. In the first part the author treats of ordnance carriages and ammunition, which are handled with distinguishing clearness. The principles and practice of gunnery are ably reviewed in the second part of the book—the writer devoting much space to the motion of projectiles. Of equal merit is the third part of the work, which is replete with suggestive remarks on the use of artillery in warfare. Colonel Owen may be fairly congratulated upon the care and accuracy with which he has compiled his valuable work. The style is good and free from verbosity, and we predict for this opportune book an extended circulation.

TABLES FOR SETTING OUT HALF-WIDTHS ON RAILWAYS, ROADS, CANALS, AND OTHER PUBLIC WORKS, TO BE APPLIED IN FIELD-WORK AND WITHOUT ANY PREVIOUS CALCULATIONS. By J. S. OLVER, C. E. London: E. and F. N. Spon. For sale by Van Nostrand.

We fear that the author of this little book has taken great pains to supply an imaginary want. His tables give the half-widths of embankments and cuttings in sidelong ground of various inclinations, the width of the road being in all cases taken as 30 ft. and the depth or height of the cutting or embankment as 60 ft., while the slopes of the work vary from $\frac{1}{8}$ to 1, to $5\frac{3}{4}$ to 1. To adapt the tables to the various widths of road-bed, and heights or depths of embankments or cuttings existing in practice, "some calculations" are necessary, and we fear that in most instances these calculations, simple as they are, and the trouble of referring to tables, will be found sufficient to deter engineers from accepting the aid Mr. Olver proposes to render them. In some instances Mr. Olver's book may be of service; but in the vast majority of cases engineers will prefer to plot the transverse sections and measure the half-widths from them in the ordinary way.

POCKET BOOK OF USEFUL FORMULÆ AND MEMORANDA FOR CIVIL AND MECHANICAL ENGINEERS. By GUILFORD L. MOLESWORTH, C. E. 17th Edition. Revised with additions. E. and F. N. Spon, 1871. For sale by Van Nostrand.

This neat little volume is a model of comprehensiveness in every respect; materially, with a thickness of $\frac{3}{4}$ of an in., it contains 440 pages measuring 5 in. by 4; yet this is no clue to its scientific qualities, for all its pages are full of such well-chosen and accurate tables on formulæ as every engineer requires from time to time to consult, and such as only a man of great diligence and experience could satisfactorily compile.

SELECT METHODS IN CHEMICAL ANALYSIS, CHIEFLY INORGANIC. By WILLIAM CROOKES, F.R.S., editor of the "Chemical News," and of the "Quarterly Journal of Science." 1 vol. 8vo, 22 woodcuts. London: Longmans. 1871. For sale by Van Nostrand.

Mr. Crookes has done good service to analytical chemistry by the production of this work, which most conveniently collects together most of the processes which have been described and are scattered through the pages of the "Chemical News" of the last 12 years—years of remarkable chemical activity and improvement in methods of analysis throughout the whole range of the science. Several volumes of this character have from time to time appeared on the Continent, one of the earliest having been that of Colonel Sobrero, of the Sardinian artillery, nearly 30 years ago, and entitled "Complement à tous les Traités Analitiques," etc. His range was very limited, and it has long ceased to be of more than historical interest. Mr. Crookes' volume, upon a wider scale, is one of the same class. It aims not at being a complete treatise on chemical analysis, but as a most important supplement to all such works; and it has this additional element of value: that its methods deal with a large number of the very rare and recently discovered elements, such as cæsium, rubidium, didymium, thallium, indium, ruthenium, etc., which are passed without notice in nearly all the systematic works on analysis; these bodies are less frequently met with because very unfrequently looked for, and so their omission in such works acts and reacts disadvantageously.

The order of sequence and the grouping of the elements for treatment in these pages is nearly the usual one. Reference to each method of detection or separation is easy, and aided by a good table of contents and a sufficient index at the end, where are to be found a few, but those very good and well arranged, tables for conversion of weights and measures, etc., etc.—*The Engineer.*

TRAVELS OF A PIONEER OF COMMERCE IN PIGTAIL AND PETTICOATS. BY T. J. COOPER, late agent for the Callcutta Chamber of Commerce. London; John Murray, 1871.

We take it to be our duty not only to notice the books of mechanical interest, but also books of merit that may possess special interest of any sort, and at any future time, to our readers. Mr. Cooper thinks that China will be opened up for English trade by engineers rather than by missionaries. He says that as an Englishman, who has lived amongst them as one of themselves, to know the Chinese middle classes and the peasantry is to like them. Kindly, courteous, yet impulsive, they are as easily moved to friendship as we now deem them readily excited to barbarous outrage. The author thinks that by and by more knowledge will lead to increased interest, and that the commerce of the West with its steamers, railways, and machinery, will be welcomed when the native mistrust is overcome. Such a movement of progress will, we hope, soon set in to save that great empire from the internal decay and ruin which now more than threaten her. To aid in this by making Englishmen better acquainted with the social and material condition of the people, and by pioneering a road for the advance of commerce, was the object of Mr. Cooper's work. The route followed was that projected by Dr. Clement Williams about ten years ago. The traveller set out from Hankow, in Chinese guise, in January, 1868. Sailed up the river to Chung-Ching, whence he proceeded with mules and a native servant towards India by way of Chen-tu-foo, Ta-tsian-loo, Dilhang, Bathang, Pamoo-tan, to Weisseefoo. His adventures and scenes have immense variety, from the sultry low-lying valley to the snows on hill ranges at the height of 20,000 ft., and from being twice made fast in the bonds of wedlock without knowing it, to his being cast into durance vile under the charge of the Mandarin of Weissle. Farther it was impossible to go, and thus baffled by the commercial jealousy, aided by political and religious fanaticism, always rampant in Eastern Thibet, Mr. Cooper had to retrace his steps backward toward to-

wards Chung-Ching and Hankow, where he arrived on the 11th of November, 1869. After remaining a month at Shanghae, Mr. Cooper again set out for Bathang, this time by way of Calcutta and the Bramapootra river. Perhaps at a future day, says Mr. Cooper, he will publish a narrative of this journey. After reaching the head-waters of the Bramapootra, and successfully passing through the savage and treacherous Mishmee tribes to the north of Assam, he reached a point on the frontiers of Thibet, not more than 120 miles from Bathang, where he was stopped by order of the Thibetan Governor of Ly-yul, and compelled after suffering much from hunger and jungle fever to return to Calcutta, not, however, relinquishing the hope of some day successfully finding the missing link in our geographical and commercial knowledge of the route from Assam to Thibet.

Before the Mohammedan rebellion in 1854-5, when the province of Yunnan teemed with a busy and prosperous people engaged in developing the enormous natural resources of their country, there was regular trade along this route; since then, none. Among the many books recently published relating to China we know of none that we would sooner think of recommending to a young engineer going to China, as a singularly accurate guide to the character of this peculiar people, and to the immense resources of their strange land.—*Mechanics' Magazine.*

Light Science for Leisure Hours. By R. A. Proctor, B. A., F. R. A. S. London: Longmans and Co. For sale by Van Nostrand.

Anything that Mr. Proctor writes is sure to meet with an attentive and appreciative public, and no writer at the present time is better able to place science before the people in an attractive and popular form. The present volume is a collection of fugitive articles contributed to various magazines and other more ephemeral publications; with many of them our readers are doubtless already acquainted. While, however, the book has no pretensions to take rank with the valuable works which have preceded it, it will prove an entertaining and instructive companion during a leisure hour at the seaside, or serve to dissipate the tedium of a journey by rail or boat. We have reprinted one of the articles—"The Usefulness of Earthquakes"—in another column.

A Manual of the Railroads of the United States, for 1871-72. Showing their mileage, stocks, bonds, cost, traffic, earnings, expenses, and organizations; with a sketch of their rise, progress, influence, etc., together with an appendix containing a full analysis of the debts of the United States and of the several States. By Henry V. Poor. New York: H. V. & H. W. Poor. For sale by Van Nostrand.

Physical Geography in its Relation to the Prevailing Winds and Currents. By John Knox Laughton, F. R. A. S., F. R. G. S. London: J. D. Potter. For sale by Van Nostrand.

This is a well printed duodecimo with few illustrations, and confines its discussions, as the title indicates, to winds and currents.

The more recent observations are well collated and ably discussed.

A Key to the Solar Compass and Surveyor's Companion. Comprising all the rules necessary for use in the field. By William A. Burt. Second edition, 118 pages. Pocket-book form. New York: D. Van Nostrand.

This affords, besides very complete instruction in the use of this ingenious instrument, some excellent exercises in Practical Astronomy. We are inclined to the belief that the best use of the Solar Compass and this Key will be found in the schools where practical methods of Surveying are made a specialty.

The practice with the Solar Compass cannot fail to give the learner greater facility in the rudimentary astronomical work sometimes required of the Transit.

Science Lectures for the People. By Professors Huxley, Roscoe, Huggins, Lockyer, Carpenter, and others. Manchester: John Heywood. London: Simpkin, Marshall & Co. For sale by Van Nostrand.

No better aids to the diffusion of scientific knowledge have ever been issued from the press than these little books. Prepared by the foremost scientific men of the age, with special reference to the needs of the unscientific reader, the most advanced views and latest achievements are set forth in a style that insures their comprehension by those even who are not accustomed to the consideration of scientific theories.

We hope these lectures will find their way to every school library in the land.

The number of lectures thus far published is 22, in three separate series of 4, 5, and 13 lectures, respectively.

MISCELLANEOUS.

American Telescopes.—In the manufacture of optical instruments, we are at this time leading all the nations of the earth. American microscopes, spectroscopes, and telescopes are certainly superior to any made in Europe, and this is acknowledged by some of the best scientific observers of England and Germany. Tolles's and Wales's objectives are of the highest excellence, and none better have ever been produced. The telescopes of the Messrs. Clark, at Cambridge, stand at the head of all instruments of this class which are now made, and their orders, from parties at home and abroad, are much greater than they can promptly meet These celebrated makers have recently received orders for *two telescopes, of 25 in. aperture,* which, when completed, will be the largest instruments in the world. The largest hitherto made has an aperture of 24 inches.

Monster Observatory.—A monster iron observatory is being erected on the roof of the Equitable Life Assurance Company, on Broadway, New York. It will be 22 ft. high, while the roof of the building is 130 ft. above the side walk. It will be constructed of iron, cased with slate, and the interior dimensions will be 10 by 14 ft. The probabilities of the weather will be indicated by balls 12 ft. in diameter, which will be displayed upon two signal staffs to be seen and understood from various points on Long Island Sound, Sandy Hook, and the inland waters of the Hudson and Harlem rivers. These will indicate where storms exist, and with how much force they are travelling. In the Equita-

ble Building will be exposed a large map, displaying all the immense territory throughout which the service has its stations, reaching from Mexico to Canada and from the Atlantic to the Pacific coast. The state of the weather will be indicated by ingenious dials at each of these stations, from which reports will be received at the Equitable every five hours. A bulletin hung by the side of the map will give the record of at least five preceding observations. The observatory in this city will form a part of an elaborate and perfect system of meteorological observations along the coast and throughout the interior.—*Am. Railway Times.*

Compressed Gun Cotton.—The terrible disasters noted from the explosion of nitro-glycerine within the last three years, have decided many against the use of this substance at all. The uses of dualin, or the newer lithofracteur, are open to similar objections, while nothing has, until lately, been found of equal explosive force with nitroglycerine. A method of using gun cotton has fortunately been discovered which will produce an explosive effect equal to that of either nitro-glycerine or dynamite, with none of the danger attendant upon the use of these substances. If guncotton be laid loosely on a surface, and lighted by contact of a lighted match or red iron, rapid combustion follows, with a dull sound, but without any explosive or violent effects. If the cotton, however, be compressed into a compact mass, and then ignited, the combustion is slower, and can be controlled to such a degree as to exhibit a smouldering or slow fire without apparent flame. If into the mass of gun-cotton so compressed a detonating percussion powder be introduced, and ignited by the spark from a battery, or by a fuse, the result is totally changed. The explosion which ensues is equal in destructive power to that of nitro-glycerine, which is exploded in the same way, and greatly superior to that of gun-cotton under ordinary circumstances. If several masses of compressed gun cotton be placed at short distances apart, and one be ignited by means of percussion powder, all the rest will explode with similar effect to that of the first. A fact of the utmost importance to those engaged in mining or blasting, is that the effect of gun cotton thus treated is equal, whether it be laid upon the surface of a rock or enclosed within the body of it. Thus the accidents resulting from drilling, charging and tamping in blasting may be avoided, together with a great economy in labor. For submarine blasting the uses of this invention are apparent, as the charge need only be enclosed in a water-tight sack or glass jar, and exploded on the surface of the obstacle to be removed. For the removal of ice in harbors or around vessels this preparation may also be used with effect, as indeed, for all the ordinary purposes to which a blasting powder is applied, with much less risk of accident or expense of preparation. After the terrible explosion of a wagon load of nitro-glycerine in the oil regions lately, the adoption of some less dangerous agent to accomplish the same purpose seems desirable, and the use of compressed guncotton to supply the desideratum.—*Iron Age.*

Clocks and Chronographs.—Mr. Norman Lockyer, in his sixth lecture at the Royal Institution, on the "Instruments used in Modern Astronomy," referred to the methods adopted for dividing and recording time. The ancients divided the day at all times of the year, from sunrise to sunset, into 12 hours of varying length; and the earliest clocks were adapted to this arrangement. Archimedes is said to have constructed a clock with wheels moved by a weight; and the first clock in England is said to have been set up in Old Palace-yard, Westminster, in 1288, by means of a fine paid by the Lord Chief Justice. After referring to other early clocks, Mr. Lockyer stated that they consisted merely of wheels moved by a weight, the means adopted to regulate the motion being successively a fly-wheel, an alternating balance, and an upright arbor, or weighted horizontal bar. An invaluable aid to astronomical science arose from Galileo's discovery, in 1639, of the isochronal property of oscillating bodies suspended by equal strings; and by Huyghens, in 1656, applying this principle to clocks, thus superseding the balance by the pendulum. Still further progress was made by the ingenuity of Hooke, Clements, Graham, and Harrison. Mr. Lockyer, by the aid of diagrams, explained these successive improvements, and then proceeded to exhibit in action a splendid modern astronomical clock, lent him by Colonel Strange, stating that the principles now demanded in such clocks are, that the weight shall be small, and the pendulum heavy, and that there shall be as little connection between the two as possible. He then adverted to the precautions necessary to be observed to preserve the pendulum from the action of the temperature as much as possible, and alluded to the advantages of the mercurial pendulum. The way in which the sidereal 24-hour clock is used with the transit instrument was then explained and illustrated, especially in what is termed "the eye and ear method," by means of which the time when a star crosses a line can be ascertained to the tenth of a second. Mr. Lockyer then referred to Sir Charles Wheatstone's patent, in 1840, for applying the electro-magnetic force to the record of very minute fractions of time, and then explained the construction of a chronograph, kindly lent to him by Colonel Strange, by means of which the results of astronomical work can be instantaneously recorded by the observer himself with the greatest ease. After noticing various forms of this invaluable apparatus, as employed by Airy, Foucault and others, Mr. Lockyer concluded by demonstrating the great importance of chronographs in the determination of the longitude of distant places, such as Washington.

A rather singular invention for remedying the actual want of fuel in private houses became very popular in Paris during the siege. They prepared cylinders of clay impregnated with bituminous substances; these combustible cylinders were used like the ordinary charcoal which is necessaay in Parisian cookery.

The Marble Trade of the Apuan Alps.—The marbles of the Apuan Alps, which are chiefly quarried at Carrara, Massa, and Serravezza, are of various qualities, but that which seems to be the *specialité* of this district is the statuary marble; and almost all the statuary and white marble employed throughout Europe and America are derived from the Apuan Alps. Statuary marble, it is true, is found also in other parts of Italy, and in Algeria and America, but either from its inferior quality, or from the small quantity which is found, the marble of Carrara and of the neighboring localities is the most esteemed, and from the richness of these quarries, and the excellence of the material

produced, the trade in statuary marble is almost a monopoly particular to this district. Under such favorable conditions, it would be surprising if the marble industry in the Apuan Alps was not flourishing; and if, however, it has not attained the development of which it is susceptible, it is still one of the most important branches of Italian trade. The annual export of marble from this district is estimated by Professor Magenta, in an interesting work, lately published in Florence, entitled "L'industria dei Marmi Apuani," at 100,000 tons, its ultimate destination being the United States, Great Britain, France, Holland, Belgium, Spain, and Russia. Leghorn alone exported, in 1866, 45,000 tons of marble in blocks; 56,000 tons, in 1867; 77,000 tons in 1868; and in 1869 and 1870 the quantity of marble shipped was somewhat less. It is remarkable that, notwithstanding the discovery, of late years, of excellent marble in America, the exports to that country are daily increasing, in spite of the high import duties which are levied by the Government in order to keep up the demand for home produce. Of the three above-mentioned localities in the Apuan Alps, Carrara occupies the first place, both as regards the quality and the abundance of its production. Upwards of 3,000 persons are employed in the quarries, and 550 at the saw-mills and *ateliers* of sculpture. The production of marble of this town is estimated at 85,000 tons, to the value of £340,000 annually, making an average price of £4 per ton. At Massa, 900 persons find employment in the quarries and workshops, and the annual quantity of marble exported is about 12,000 tons. In the territory of Serravezza, there are at present more than 100 quarries worked, producing annually 25,000 tons of marble, chiefly in slabs, for table tops and other small pieces. Although great progress has been made during late years in this industry, there is still room for improvement. The production is still in the hands of small capitalists, who, for the want of the spirit of association, and alone, are unable to introduce those improvements which might advantageously be adopted in the getting out of the stone, as also in the process now used for working the marble after it is quarried. The education of the workmen requires to be attended to, for even the foremen are in many cases uneducated. The road communication cannot be spoken of very highly, and in many cases they are mere tracks, rendering the transport costly and often impossible, as in the Val d Arni, which contains rich beds of marble, which are but little worked on this account.

A Curious Calculation Concerning the War Indemnity to be Paid to Prussia by France.—The "Independence Belge" produces the following scientific curiosity in reference to the amount exacted from France by Prussia. It should be understood that a "milliard" is one thousand millions, say one-half the debt of the United States in dollars:

"On the 31st of December next, there will not have elapsed a milliard of minutes of time since the beginning of the Christian era; that milliard of minutes will not be complete before the date of 28th of March, 1901. If, consequently, there had been put in a safe a 5-franc piece every minute since the beginning of the era alluded to, the indemnity of five milliards of francs would not be paid off in capital—interest exclusive—before midday of the 28th of March, 1901. The 5-franc piece has a weight of 25 grms., and the five milliards will, therefore, weigh 25,000,000 of kilos., a weight which, if loaded on railway trucks, each containing 5,000 kilos. (5 tons), would require 5,000 trucks; estimated in copper, the weight alluded to would be 500,000,000 of kilos., and would require 100,000 railway trucks for being conveyed. The diameter of the 5-franc piece is 37 millimetres; if, therefore, one milliard of these pieces are laid down so as to join closely, this would give a length of 37,000,000 metres, equal to 37,000 kilometres, equal to 74 times the distance from Paris to Strasbourg, which is 500 kilometres, and more than 32½ times the distance from Paris to Berlin, equal to 1,134 kilometres. It would, therefore, be possible to pave, with one milliard of 5-franc pieces a road from Paris to Strasbourg, which road would have a width of 74 5-franc pieces, equal to 2,738 metres; or a similar road might be made from Paris to Berlin, and have a width of nearly 33 of the same pieces, that is, 1.20 metre. In order to cover a surface of a square metre, 730 5-franc pieces are required; one milliard of these pieces will, therefore, cover 136 hectares, 98 ares, 63 centiares; that is to say, nearly three times more than the surface occupied in the Champ de Mars at Paris by the Exposition of 1867, which only occupied a space of 46 hectares; but the indemnity to be paid is five milliard of francs, which, put together, would cover a surface of 684 hectares, 93 ares, 15 centiares; that is, fifteen times more than the place occupied by the Exposition just named. When 3 pieces of 5 francs are placed upon each other, the height of the pile is equal to 8 millimetres; the height attained by piling upon each other one milliard of these pieces would be 2,666,666 metres, 66 centimes, that is to say, if placed edgewise, on the ground, the length would be within 2,666 kilometres, which is very nearly the distance from Paris to St. Petersburg. The kilo. of one and of five-franc pieces contains, in each case, 900 grms. of pure silver."

The Institution of Civil Engineers.—At a recent meeting of the members of this Society, Mr. C. B. Vignoles, F.R.S., the President, announced that he proposed to give a *conversazione* at the House of the Institution on Tuesday, the 6th of June, for which occasion he should be glad to receive the loan of any engineering models, small and light pieces of mechanism, or scientific instruments, as well as of paintings, or watercolor drawings, by ancient and modern masters of eminence, depicting some engineering work, object or matter of interest, as "a bridge, lighthouse, aqueduct, harbor, etc., set in its appropriate landscape."

A two hundred-gallon self-regulating, cleanable, cement-lined tank filter, one of that class recently invented and patented by Captain Crease, Royal Marine Artillery, has for the last 3 months being on trial in H. M. S. Minotaur, the flag-ship of the channel squadron, against one of Atkins' filters of the same capacity. The trial has resulted, very much in favor of Captain Crease's tank filter, which has more than accomplished all that its performances at its official trial in January last promised. This further trial has proved beyond a doubt the possibility of supplying a large ship's company with sufficient pure water for drinking purposes. It appears that the tank filter will be generally adopted throughout the service.

VAN NOSTRAND'S ECLECTIC ENGINEERING MAGAZINE.

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THE MONT CENIS TUNNEL.

(*Continued from page* 121.)

THE GEOLOGY OF THE TUNNEL.

Before considering the mineralogical and geological formation of that portion of the Alps separating Bardonnèche from Modane, it may be interesting to devote a short space to a review of the geological characteristics of the Alps in general.

The word "Alpen" is of great antiquity, and it is believed that it has been transferred from the language of the most ancient inhabitants of Italy. It is asserted that it is derived from the Sabines, the two monosyllables "Alp" and "Pen" of which it is composed, meaning repectively "white" and "head," the combination having reference to the perpetual snows covering the higher summits of the chain. It is not known why this name, which might well be applied to any snow-covered mountains, should only have been given to those surrounding Northern Italy.

The Mont Schiavo forms the beginning of the Italian Alps, on the Mediterranean side, and they terminate with Mont Bittoray at the Adriatic, not far from the city of Fiume. The ridge extends in a curve about 955 miles in length taken along the peaks of the chain. This great circle of mountains surrounding Northern Italy, bears very different aspects on its inner and its outer faces. If we start from the highest peaks of the Alps, and descend on the outer side, we find a long continuation of ascents and descents, with comparatively easy slopes, whereas on the inner faces the plains are reached by a series of very abrupt spurs. Thus, for instance, Mont Blanc, the highest peak of the Alps, offers an easy ascent from Savoy, while on the Italian side it rises almost perpendicularly to a vast height above the valley of Aosta. So also, while the river Po, at Saluzzio, falls 5,249 ft. in a distance of 21 miles, the Rhine, in descending from the same height, runs as far as Lake Constance, a distance of 92 miles.

It may be assumed that the whole Alpine chain is bounded by a line, drawn at the foot of the mountains through Mondovi, Sallizzo, Pinerolo, Ivrea, Biella, Como, Bergamo, Brescia, Peschiera, Udine, Trieste, and Pola, and beyond Italy by another line, which beginning at Mondovi crosses Mont Schiavo to Abenga, as far as Nice, and thence passes by Entrevaux, Seyne, Geneva, Villeneuve, Altorf, Innsbrük, and Laïbach; thence, crossing the top of the Bittoray, it reaches Pola, and completes the enclosing line.

The Italian Alps form a series of clusters or heads, the principal of which are 7 in number, and these have been named from the mountain that has the greatest number of spurs, and not from the one most conspicuous in height.

They are :

1. The group of the Stura and of the 4 Bishoprics.

2. The group of Bardonecchia or of the Tabor.

3. The group of the Isera or of Mont Iseran.
4. The group of Mont Blanc.
5. The group of Mont Saint Gothard.
6. The group of Malaggio.
7. The group of the Pizzo dei tre Signori.

The group of Bardonecchia is situated north of the sources of the torrent Dora Riparia, and it extends from Mont Cenis to Mont Ginevro, giving birth to the two principal branches of the Dora, one of which springs from Mont Ginevro, while the other descends from the top of the Great Miol, and is at first known as the Ripa, and afterwards the Dora Riparia.

The idea of opening the tunnel through the Alps with the object of facilitating the communication between England and France, is due to M. Médail, a native of Bardonnèche. This gentleman, whose pursuits led him frequently across the mountains that surrounded his native village, ascertained the way in which, from the valley of the Arc, at whose head is Modane, at the foot of the western side of Mont Frejus, it was possible to descend to the banks of the Rhone, by continually skirting the torrent of the Arc without any rapid gradients, by keeping always on the sides of the high spurs to the right and left. The same facilities seemed to be offered by nature for the construction of a railway from Bardonnèche to Susa. The only obstacle in uniting France and Italy was therefore the construction of a tunnel under Mont Frejus, so as to join Bardonnèche and Modane. This point of crossing was the only one that could be selected, involving a tunnel of no greater length than the one that has been constructed. In 1841 M. Médail published a pamphlet at Lyons upon this subject. The work, however, obtained no attention, and the author died without the satisfaction of seeing even the first steps taken in the matter which he had advocated.

When the construction of the Mont Cenis tunnel was first discussed as a practicable and probable scheme, the popular notions as to the geological difficulties that would be encountered were as numerous as they were original, and were equalled by the prejudices that arose on all sides, springing even from high scientific sources. To investigate the validity of the opposition coming from responsible persons, the Sardinian Government requested Professor Angelo Sisimunda to report fully upon the prospects of the work. We shall here only briefly allude to the results of his labors, which were presented in due course to the Secretary of State for Public Works.

Professor Sisimunda found the distribution of rocks between Bardonnèche and Modane to be as follows: Arenaceous, micaceous, and schistous united together—quartzites—chalk (internally anhydrite) with limestone and sometimes with dolomites, and lastly crystalline schistous lime, alternating with argillaceous and decomposed schists.

Professor Sisimunda divided these rocks into 3 groups, and named them as follows:

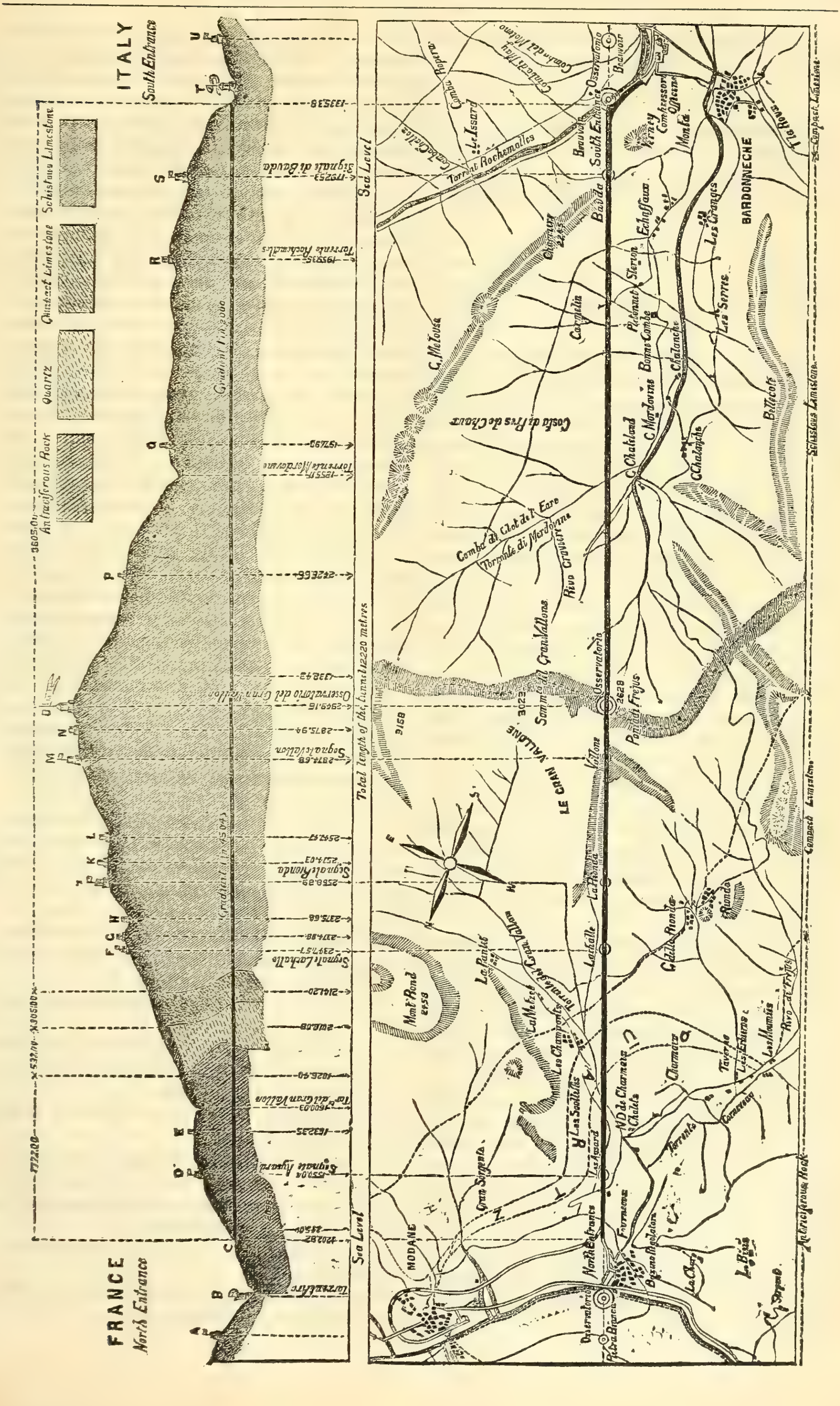
1. Superior group. Anthracite, which includes the micaceous arevania, with schists and quartzites.

2. Group represented by oolite, and including the lime and chalk. This group is, according to the report, a continuation of the great stratum of the same nature near Villette, in Tarantasia.

3. Inferior group. Anthracite and schistous lime, with metamorphic and argillaceous schists.

It is easy to prove a discordance in the stratification between the schistous lime of the inferior anthraciferous system and silicious lime, the chalk and dolomite representing the superior lias formation, and the inferior oolite. This fact is almost universal in the Alpine chain, and is caused by a constant undulation in the rocks. The irregularity of stratification between the silicious lime and the layer of quartzite that is above it, and which is almost vertical, might be the effect of the ruption which has taken place, and which runs across the Alps in a direction from south to north. The displacement of the rocks having taken place in the direction of the depth of the formation, the succession of the strata would not, according to Professor Sisimunda, have undergone any change from the ruption.

The plan and section of Mont Frejus on the following page show the position of the different strata to which we have referred. In order to give an idea of the dimensions of the strata, it may be remarked that their widths vary on the outer surface and within the mountain;


FRANCE
North Entrance
ITALY
South Entrance
Antraciferous Rock
Quartz
Compact Limestone
Schistous Limestone
Sea Level
Total length of the tunnel 12220 metres
MODANE
BARDONNECHE
LE GRAN VALLONE

the following table of inner and outer profiles gives the exact figures :

	Ft.	In.
On the Surface.		
Anthraciferous rocks—widths of stratum	5,814	3
Quartzites	1,761	9
Compact limestone and dolomites	1,004	0
Schistous limestone	31,512	4
Inside and along the Tunnel.		
Anthraciferous rocks— width of stratum	6,879	3
Quartzites	1,274	6
Compact limestone and dolomites	1,166	8
Schistous limestone	3,0774	2

Upon the surface on the Bardonnèche side the schistous limestone has an average dip varying between 20 deg. and 25 deg. to the west, and from 40 deg. to 45 deg. on the west, increasing at the Col de Frejus to as much as 50 deg. The chalk is so distorted that the stratification is not recognizable. The quartzites are nearly vertical at the commencement of the stratum; they incline towards the south-west at an angle varying from 90 deg. to 65 deg. The anthraciferous sandstone inclines in some parts towards the north-west, at others to the south-east, and at the extreme point it is nearly vertical.

Inside the mountain along the tunnel the schistous limestone inclines from north-west to east at an angle varying from 5 deg. to 10 deg. The chalk stratum is also here indistinguishable. The quartzites incline to the north-east at varying angles between 50 deg. and 60 deg., then it becomes vertical. The anthraciferous sandstone dips from north-west to east, with angles of from 50 deg. to 80 deg.

In the course of the tunnel excavation on the Modane side, frequent changes were observed in the degrees of the inclination of the rocks, but the general direction of this inclination always tended towards the west; it was also observed that before reaching the quartzites, the strata made a curve resembling the letter C with the convex parts turned eastwards.

In the tunnel quartzite was met with about 295 ft. east of the spot that was anticipated by Professor Sisimunda in his report presented to the Government in 1845.

The direction of the tunnel is nearly north 14 deg. west, and the axis strikes the strata at angles varying from 34 deg. to 40 deg.

As regards the different degrees of density of the rocks that compose the three different groups, of course the quartzites were the hardest and the schistous limestone the softest. But as regards the facility of excavation by mechanical means, all miners know that homogeneous rocks are more convenient to excavate than others which are variable in quality, soft in some places, and mixed with quartzites in others. The quartzites on the Modane side presented such an extraordinary degree of hardness that steel and percussion seemed to have no effect upon them, and several hundreds of steel chisels (as we shall hereafter see) have been worn out dailyto make a few insignificant holes, notwithstanding the enormous mechanical appliances employed. The quartzites were indeed at times as hard as regular quartz crystals, translucent, and sometimes slightly colored like amethyst. We shall see further on how great the efforts were that had to be employed to pierce through the wall which nature appeared to have erected to bar the daring undertaking. It was ascertained with certainty that the rocks were less hard on the line of tunnel than on the surface of the mountain ; the difference may be chiefly attributed to the action of the atmosphere upon the latter. The frequent changes in the long series of schistous limestone has to be attributed to metamorphic action.

As this stratum is the predominating one, we shall give some particulars as to its nature. Starting from the south opening, the aspect changes in the following manner:

At 1,640 ft. it was granulous limestone, gary, hard, uniform in color, with splits in regular layers.

At 4,880 ft. it was black limestone, hard and laminating.

At 5,570 ft. the limestone was colored with oxides, and presented the appearance of eufotide.

From 6,161 ft. to 6,286 ft. very hard limestone.

At 7,020 ft. very hard limestone, gray, and veined with white granules.

At 8,202 ft. schistous limestone, black, with signs of graphite.

At 9,840 ft. the same, but splitting in layers.

At 13,097 ft. schistous limestone, not so compact, with graphite.

At 13,123 ft. very hard black limestone, granulous, like granite.

At 14,960 ft. very black limestone, with hornblende, but not very hard.

At 15,380 ft. black limestone, mixed with graphite and albite.

At 19,000 ft. white limestone, a little crystallized.

At 19,284 ft. black limestone, not hard, combined with layers of very hard white limestone.

These particulars, together with the plan and section upon page 227, will, we hope, give clear and detailed information upon the geological character of the Alps along the axis of the tunnel.

THE EARTH A MAGNET.

From Proctor's "Light Science for Leisure Hours."

There is a very prevalent but erroneous opinion, that the magnetic needle points to the north. We remember well how we discovered in our boyhood that the needle does not point to the north, for the discovery was impressed upon us in a very unpleasant manner.

We had purchased a pocket compass and were very anxious—not, indeed, to test the instrument, since we placed implicit reliance upon its indications—but to make use of it as a guide across unknown regions.

Not many miles from where we lived lay Cobham Wood, no very extensive forest certainly, but large enough to lose one's self in. Thither accordingly we proceeded with three school-fellows. When we had lost ourselves we gleefully called the compass into action, and made from the wood in a direction which we supposed would lead us home. We travelled on with full confidence in our pocket guide; at each turning we consulted it in an artistic manner, carefully poising it and waiting till its vibrations ceased. But when we had travelled some two or three miles without seeing any house or road that we recognized, matters assumed a less cheerful aspect. We were unwilling to compromise our dignity as explorers by asking the way, a proceeding which no precedent in the history of our favorite travellers allowed us to think of. But evening came on and with it a summer thunder shower. We were getting thoroughly tired out and the *hæc olim meminisse juvabit* with which we had comforted ourselves began to lose its force. When at length we yielded, we learned that we had gone many miles out of our road, and we did not reach home till several hours after dark. How it fared with our school-fellows we know not, but a result overtook ourselves personally for which there is no precedent, so far as we are aware, in the records of exploring expeditions. Also the offending compass was confiscated by justly indignant parents, so that for a long while the cause of our troubles was a mystery to us. We now know that instead of pointing due north, the compass pointed more than 20 deg. toward the west, or nearly to the quarter called by sailors north-northwest. No wonder, therefore, that we went astray when we followed a guide so untrustworthy.

The peculiarity that the magnet needle does not in general point to the north, is the first of a series of peculiarities which we now propose briefly to describe. The irregularity is called by the sailors the needle's *variation*, but the term more commonly used by scientific men is the *declination* of the needle. It was probably discovered a long time ago, for 800 years before our era the Chinese applied the magnet's directive force to guide them in journeying over the great Asiatic plains; and they must soon have detected so marked a peculiarity. Instead of a ship's compass, they made use of a magnetic car, on the front of which a floating needle carried a small figure whose outstretched arm pointed southwards. We have no record, however, of their discovery of the declination, and know only that they were acquainted with it in the 12th century. The declination was discovered, independently, by European observers, in the 13th century.

As we travel from place to place, the declination of the needle is found to vary. Christopher Columbus was the first to detect this. He discovered it on the 13th of September, 1492, during his first voyage, and when he was 600 miles from Ferro, the most westerly of the Canary

Islands. He found that the declination, which was towards the east in Europe, passed to the west, and increased continually as he travelled westwards.

But here we see the first trace of a yet more singular peculiarity. We have said that at present the declination is towards the west in Europe. In Columbus's time it was towards the east. Thus we learn that the declination varies with the progress of time as well as with change of place.

The genius of modern science is a weighing and a measuring one. Men are not satisfied nowadays with knowing that a pecularity exists; they seek to determine its extent, how far it is variable, whether from time to time, or from place to place, and so on. Now the results of such inquiries applied to the magnetic declination have proved exceedingly interesting. We find first that the world may be divided into two unequal portions, over one of which the needle has a westerly, and over the other an easterly declination Along the boundary line, of course, the needle points due north.

England is situated in the region of westerly magnets. This region includes all Europe except the northeastern parts of Russia, Turkey, Arabia, and the whole of Africa, the greater part of the Indian Ocean and the western parts of Australia, nearly the whole of the Atlantic Ocean, Greenland, the eastern parts of Canada, and a small slice from the northeastern part of Brazil.

All these form one region of westerly declination; but, singularly enough, there lies in the very heart of the remaining and larger region of easterly magnets an oval space of a contrary character. This space includes the Japanese Islands, Manchouria, and the eastern parts of China. It is very noteworthy also that in the westerly region the declination is much greater than in the easterly. Over the whole of Asia, for instance, the needle points almost due north. On the contrary, in the north of Greenland, and of Baffin's Bay, the magnetic needle points due west; while still further to the north (a little westerly) we find the needle pointing with its north end directly towards the south.

In the presence of these peculiarities it would be pleasant to speculate.

We might imagine the existence of powerfully magnetic *veins* in the earth's solid mass, coercing the magnetic needle from a full obedience to the true polar summons. Or the comparative effects of oceans and of continents might be called into play. But, unfortunately for all this, we have to reconcile views founded on *fixed* relations presented by the earth with the process of *change* indicated above. Let us consider the declination of England alone.

In the 15th century there was an easterly declination. This gradully diminished, so that in about the year 1657 the needle pointed due north. After this the needle pointed towards the west, and continually more and more, so that scientific men, having had experience only of a continual shifting of the needle in one direction, began to form the opinion that this change would continue, so that the needle would pass through north-west and west to the south. In fact, it was imagined that the motion of the needle would resemble that of the hands of a watch, only in a reversed direction.

But before long, observant men detected a gradual diminution in the needle's westerly motion. Arago, the distinguished French astronomer and physicist, was the first (we believe) to point out that "the progressive movement of the magnetic needle towards the west appeared to have become continually slower of late years" (he wrote in 1814); "which seemed to indicate that after some little time longer it might become retrograde." Three years later, namely on the 10th of February, 1817, Arago asserted definitely that the retrograde movement of the magnetic needle had commenced to be perceptible. Colonel Beaufoy at first oppugned Arago's conclusion, for he found from observations made in London during the years 1817–1819, that the westerly motion still continued. But he had omitted to take notice of one very simple fact, viz. that London and Paris are two different places. A few years later the retrograde motion became perceptible at London also, and it has now been established by the observations of 40 years. It appears from a careful comparison of Beaufoy's observations that the needle reached the limit of its western digression (at Greenwich) in March, 1819, at which time the declination was nearly 25 deg. In Paris, on the contrary, the needle had reached its greatest western digression

(about 22½ deg.) in 1814. It is rather singular that, although at Paris the retrograde motion thus presented itself 5 years earlier than in London, the needle pointed due north at Paris 6 years later than in London, viz. in 1663. Perhaps the greater amplitude of the needle's London digression may explain this peculiarity.

"It was already sufficiently difficult," says Arago, "to imagine what could be the kind of change in the constitution of the globe which could act during 153 years in gradually transferring the direction of the magnetic needle from due north to 23 deg. west of north. We see that it is now necessary to explain moreover how it has happened that this gradual change has ceased, and has given place to a return towards the preceding state of the globe."

"How is it," he persistently asks, "that the directive action of the globe, which clearly must result from the action of molecules of which the globe is composed, can be thus variable while the number, position, and temperature of these molecules, and, as far as we know, all their other physical properties, remain constant?"

But we have considered only a single region of the earth's surface. Arago's opinion will seem more just when we examine the change which has taken place in what we may term the magnetic aspect of the whole globe.

The line which separates the region of westerly magnets from the region of easterly magnets now runs, as we have said, across Canada and eastern Brazil in one hemisphere, and across Russia, Asiatic Turkey, Indian Ocean, and West Australia in the other; besides having an outlying oval to the east of the Asiatic continent. Now these lines have swept round a part of the globe's circuit in a most singular manner since 1600. They have varied alike in direction and complexity. The Siberian oval, now distinct, was in 1787 merely a loop of the eastern line, of no declination. The oval appears now to be continually diminishing, and will one day probably disappear.

We find here presented to us a phenomenon as mysterious, as astonishing, and as worthy of careful study as any embraced in the wide domains of science. But other peculiarities await our notice.

If a magnetic needle of suitable length be carefully poised on a fine point, or, better, be suspended from a silk thread without torsion, it will be found to exhibit each day two small, but clearly perceptible, oscillations. M. Arago, from a careful series of observations, deduced the following results :

At about 11 at night the north end of the needle begins to move from west to east, and having reached its greatest easterly excursion at about 8¼ in the morning, returns toward the west to attain its greatest westerly excursion at 1¼. It then moves again to the east, and having reached its greatest easterly excursion at 8½, returns to the west, and attains its greatest westerly excursion at 11, as at starting. Of course these excursions take place on either side of the mean position of the needle, and as the excursions are small, never exceeding the fifth part of a degree, while the mean position of the needle lies some 20 deg. to the west of north, it is clear that the excursions are only nominally eastern and western, the needle pointing throughout far to the west.

Now, if we remember that the north end of the needle is that farthest from the sun, it will be easy to trace in M. Arago's results a sort of an effort to turn towards the sun—not merely when that luminary is above the horizon, but during his nocturnal path also. We are prepared, therefore, to expect that a variation, having an annual period, shall appear on a close observation of our suspended needle. Such a variation has long since been recognized. It is found that in the summer of both hemispheres the daily variation is exaggerated, while in the winter it is diminished. But besides the divergence of a magnetized needle from the north pole, there is a divergence from the horizontal position, which must now claim our attention. If a non-magnetic needle be carefully suspended so as to rest horizontally, and be then magnetized, it will be found no longer to preserve that position. The northern end dips very sensibly. This happens in our hemisphere. In the southern it is the southern end that dips. It is clear, therefore, that if we travel from one hemisphere to the other we must find the northern dip of the needle gradually diminishing, till at some point near the equator the needle is horizontal; and as

we pass thence to southern regions, a gradually increasing southern inclination is presented. This has been found to be the case, and the position of the line along which there is no inclination (called the *magnetic equator*) has been traced around the globe. It is not coincident with the earth's equator, but crosses that circle at an angle of 12 deg., passing from north to south of the equator in longitude 30 deg. west of Greenwich, and from south to north in longitude 187 deg. east of Greenwich. The form of the line is not exactly that of a great circle, but presents here and there (and especially where it crosses the Atlantic) perceptible excursions from such a figure. At 2 points on the earth's globe the needle will rest in a vertical position. These are the magnetic poles of the earth.

The northern magnetic pole was reached by Sir J. G. Ross, and lies in 70 deg. north latitude and 263 deg. east longitude, that is, to the north of the American continent, and not very far from Boothia Gulf. One of the objects with which Ross set out on his celebrated expedition to the Antarctic seas was the discovery, if possible, of the southern magnetic pole. In this he was not successful. Twice he was in hopes of attaining his object, but each time he was stopped by a barrier of land. He approached so near, however, to the pole, that the needle was inclined at an angle of nearly 90 deg. to the horizon, and he was able to assign to the southern pole a position in 75 deg. south latitude and 154 deg. east longitude. It is not probable, we should imagine, that either pole is fixed, since we shall now see that the inclination, like the declination of the magnetic needle, is variable from time to time as well as from place to place; and in particular the magnetic equator is apparently subjected to a slow but uniform process of change.

Arago tells us that the inclination of the needle at Paris has been observed to diminish, year by year, since 1671. At that time the inclination was no less than 75 deg.; in other words, the needle was inclined only 15 deg. to the vertical. In 1791 the inclination was less than 71 deg. In 1831 it was less than 68 deg. In like manner, the inclination at London has been observed to diminish from 72 deg. in 1786 to 70 deg. in 1804, and thence to 68 deg. at the present time.

It might be anticipated from such changes as these that the magnetic equator would be found to be changing in position. Nay, we can even guess in which way it must be changing. For since the inclination is diminishing at London and Paris, the magnetic equator must be approaching these places, and this (in the present position of the curve) can only happen by a gradual shifting of the magnetic equator from east to west along the true equator. This motion has been found to be really taking place. It is supposed that the movement is accompanied by a change of form; but more observations are necessary to establish this interesting point.

Can it be doubted that while these changes are taking place the magnetic poles also are slowly shifting round the true pole? Must not the northern pole, for instance, be further from Paris, now that the needle is inclined more than 23 deg. from the vertical, than in 1671, when the inclination was only 15 deg. It appears obvious that this must be so, and we deduce the interesting conclusion that each of the magnetic poles is rotating around the earth's axis.

But there is another peculiarity of the needle which is as noteworthy as any of those we have spoken about. We refer to the intensity of the magnetic action—the energy with which the needle seeks its position of rest. This is not only variable from place to place, but from time to time, and is further subject to sudden changes of a very singular character.

It might be expected that where the dip is greater the directive energy of the magnet would be proportionately great. And this is found to be approximately the case. Accordingly the magnetic equator is very nearly coincident with the equator of least intensity, but not exactly. As we approach the magnetic poles we find a more considerable divergence, so that instead of there being a northern pole of greatest intensity nearly coincident with the northern magnetic pole, which we have seen lies to the north of the American continent, there are two northern poles one in Siberia, nearly at the point where the river Lena crosses the Arctic circle; the other not so far to the north, only a few deg. north in fact of Lake Superior. In the south, in a like manner, there are also 2 poles, one on the Antarctic circle,

about 130 deg. east long. in Adelie Island, the other not yet precisely determined, but supposed to lie or about to lie on about the 24th deg. of long., and south of the Antarctic circle. Singularly enough, there is a line of lower intensity running right around the earth along the valleys of the two great oceans, passing through Behring's Straits, and bisecting the Pacific, on one side of the globe, and passing out of the Arctic Sea by Spitzbergen, and down the Atlantic on the other.

Colonel Sabine discovered that the intensity of the magnetic action varies during the course of the year. It is greatest in December and January in both hemispheres. If the intensity had been greatest in winter, one would have been disposed to have assigned seasonal variation of temperature as the cause of the change. But as the epoch is the same for both hemispheres, we must seek another cause.

Is there any astronomical element which seems to correspond with the law discovered by Sabine? There is one very important element: the position of the perihelion of the earth's orbit is such that the earth is nearest to the sun on about the 31st of December or the 1st of January. There seems nothing rashly speculative, then, in concluding that the sun exercises a magnetic influence on the earth, varying according to the distance of the earth from the sun. Nay, Sabine's results seem to point very distinctly to the law of variation. For, although the number of observations is not as yet very great, and the extreme delicacy of the variation renders the determination of its amount very difficult, enough has been done to show that in all probability the sun's influence varies according to the same law as gravity, that is, inversely as the square of the distance.

That the sun, the source of light and heat, and the great gravitating centre of the solar system, should exercise a magnetic influence upon the earth, and that this influence should vary according to the same law as gravity, or as the distribution of light and heat, will not appear perhaps very surprising. But the discovery by Sabine that *the moon* exercises a distinctly traceable effect upon the magnetic needle seems to us a very remarkable one. We receive very little light from the moon, much less (in comparison with the sun's light) than most persons would suppose, and we get absolutely no perceptible heat from her. Therefore, it would seem rather to the influence of mass and proximity that the magnetic disturbances caused by the moon must be ascribed. But if the moon exercises an influence in this way, why should not the planets? We shall see that there is evidence of some such influence being exerted by these bodies. More mysterious, if possible, than any of the facts we have discussed, is the phenomenon of *magnetic storms.* The needle has been exhibiting for several weeks the most perfect uniformity of oscillation. Day after day the careful microscopic observation of the needle's progress has revealed a steady swaying to and fro, such as may be seen in the masts of a stately ship at anchor on the scarce-heaving breast of ocean. Suddenly a change is noted; irregular jerking movements are perceptible, totally distinct from the regular periodic oscillations. A magnetic storm is in progress. But where is the centre of disturbance, and what are the limits of the storm? The answer is remarkable: If the jerking movements observed in places spread over very large regions of the earth—and in some well-authenticated cases over the whole earth—be compared with the local time, it is found that (allowances being made for difference of longitude) *they occur precisely at the same instant.* The magnetic vibrations thrill in one moment through the whole frame of our earth. But a very singular circumstance is observed to characterize these magnetic storms. They are nearly always observed to be accompanied by the exhibition of the aurora in high latitudes, northern and southern. Probably they never happen without such a display; but numbers of auroras escape our notice. The converse proposition, however, *has* been established as an universal one. No great display of the aurora ever occurs without a strongly-marked magnetic storm.

Magnetic storms last sometimes for several hours or even days.

Remembering the influence which the sun has been found to exercise upon the magnetic needle, the question will naturally arise, has the sun anything to do with magnetic storms? We have clear evidence that he has. On the 1st of September, 1859, Messrs. Carrington and

Hodgson were observing the sun, one at Oxford, and the other in London. Their scrutiny was directed to certain large spots which, at that time, marked the sun's face. Suddenly, a bright light was seen by each observer to break out on the sun's surface, and to travel, slowly in appearance, but in reality at the rate of about 7,000 miles in a minute, across a part of the solar disc. Now it was found afterwards that the self-registering magnetic instruments at Kew had made at that very instant a strongly marked jerk. It was learned that at that moment a magnetic storm prevailed at the West Indies, in South America, and in Australia. The signal-men in the telegraph stations at Washington and Philadelphia received strong electric shocks; the pen of Bain's telegraph was followed by a flame of fire; and in Norway the telegraphic machinery was set on fire. At night great auroras were seen in both hemispheres. It is impossible not to connect these startling magnetic indications with the remarkable appearance observed upon the sun's disc.

But there is other evidence. Magnetic storms prevail more commonly in some years than in others. In those years in which they occur most frequently it is found that the ordinary oscillations of the magnetic needle are more extensive than usual. Now, when these peculiarities had been noticed for many years, it was found that there was an alternate and systematic increase and diminution in the intensity of magnetic action, and that the period of the variation was about 11 years. But, at the same time, a diligent observer had been recording the appearance of the sun's face from day to day, and from year to year.

He had found that the solar spots are in some years more freely displayed than in others, and he had determined the period in which the spots are successively presented with maximum frequency to be about 11 years. On a comparison of the two sets of observations, it was found (and has now been placed beyond a doubt by many years of continued observations) that magnetic perturbations are most energetic when the sun is most spotted, and *vice versa*.

For so remarkable a phenomenon as this, none but a cosmetical cause can suffice. We can neither say that the spots cause the magnetic storms, nor that the magnetic storms cause the spots. We must seek for a cause producing at once both sets of phenomena. There is as yet no certainty in this matter, but it seems as if philosophers would soon be able to trace in the disturbing action of the planets upon the solar atmosphere the cause as well of the marked period of 11 years, as of other less distinctly marked periods, which a diligent observation of solar phenomena is beginning to educe.

PROGRESS OF THE IRON AND STEEL INDUSTRIES IN FOREIGN COUNTRIES.

By DAVID FORBES, F.R.S., &c.

From "The Journal of the Iron and Steel Institute."

II.

In accordance with the views enunciated in the first of these reports, their contents will be in future arranged under two heads, viz.:—

A. Metallurgical topography, embracing all information possessing a strictly local interest in connection with the iron and steel manufactures in the different countries alluded to in these reports; and

B. Metallurgical technology, which will contain descriptions and results of new processes, improvements, machinery, physical or chemical investigations, etc., directly or indirectly connected with the metallurgy of iron and steel in foreign countries.

A. *Metallurgical Topography.*

Austria.—A recent work, edited by F. M. Friese, one of the Government mining officials, gives full statistical data as to the production of iron in this country. It embraces the years from 1826 to 1868, in which latter year the total make of pig iron amounted to 6,698,547 centners, or 329,718 English tons. Details from official sources are given of the production of the ironworks, taken separately, and their

position shown upon a map, which accompanies this book, "Uebersicht der Roheisen Produktion der Oesterreichischen Monarchie, von F. M. Friese, K. K. Berghauptman, mit 9 Tabellen, u. 1 Karte, Vien 1870, Waldheim."

A sketch of the industrial history of the Horovitzer Ironworks in Bohemia, by Strippelmann, has appeared in the February and March numbers of the "Berg u. Huetten. Zeit." It may be mentioned that the ironworks of this district are probably some of the oldest on record, for, although the historian Hajek dates the commencement of Bohemian iron metallurgy in the year 777, and Karsten puts it as late as the 9th century, it appears that mention is made of these works by Pubitschka in A. D. 596. In the "Zeitsch. d. Berg. u. Huetten. Vereins f. Kärnthen," a paper is given by W. Hupfeld on the results as yet obtained from smelting iron ores with coke in Carinthia; whilst in the same number is a description of the Reichenberge spathic iron mines near Assling; and in the "Berggeist," 1870, No. 15, a notice of the great iron deposits at Eisenerz, in Steiermark.

At the rolling mills of the Southern Railway in Gratz, the old rails, crop ends, and scrap are heated in a gas furnace, and then added to a bath of good gray pig iron, melted with some spiegeleisen in a Siemens-Martin furnace. When the sample shows that the desired quality of steel is attained, the metal is tapped into large pouring pots lined with clay, from which the ingots are filled. The bottom of the furnace is made of quartz sand, so arranged as to be kept cool by a current of air, whilst the sides and roof are of Dinas bricks. ("Zeitsch. d. Deutsch, Oesterr. Eisen. Stahl. u. Maschin. Industrie." 1870.)

Knut Styffe's report on the iron metallurgy of 1867, as represented by the Paris Exhibition, has been translated from the Swedish into German by Herr Tunner.

Since the publication of the last quarterly report, we have received Professor Kerperley's report on the advances made in iron smelting in the year 1868, only very recently published, "Bericht ueber die Fortschritte der Eisenhütten Technik, im Jahre, 1868, Leipzig, Felix," and need hardly add that it fully maintains the reputation of its predecessors, and it is much to be regretted that we have no similar work in England.

Belgium.—The iron trade of this country has, during the last three months, remained in much the same depressed condition as during the previous quarter, the bright hopes of its recovery, which the termination of the Franco-German war gave rise to, having for the time at least been overclouded by the effects of the civil war now raging in France.

With regard to the home trade, orders, especially for plates, foundry pig, slit rods, and merchant iron, have been tolerably abundant, and the demand much greater than could have been expected under the circumstances; but this has not been the case with the export trade, which has been extremely depressed—especially so for rails; and, as is well known, the iron industry of Belgium must always be mainly dependent upon its exportation. Under the impression that the return of peace would cause a sudden and important reaction in favor of the Belgian iron trade, several of the proprietors and companies, in order to meet the expected demand, and probably also with the desire of keeping their men together and in employment during this period of depression, have occupied themselves in enlarging or otherwise increasing the capabilities of their works; thus, Messrs. Dordolot Frères have been authorized by royal decree to add a fourth blast furnace, along with three steam boilers, to their Bouffioulx Works; the Société Anonyme de Grivegnée was authorized to add to their works, ten puddling furnaces, one 15-horse power steam hammer, one roughing mill, ten cylindrical boilers to work at 60 lbs. pressure, and to be heated from the waste flames from the puddling furnaces, along with two more steam engines of respectively 20 and 2 horse power, the former to work the weighing trains, and the latter as a feed engine. The extension of the Clabecq Works, and those of the Juville Rolling Mills Co., are likewise authorized.

The civil war in France, following immediately upon the announcement of peace with Germany, has now still further postponed the good time supposed to be coming for the iron works, and created a feeling of despondency in many of those connected with the Belgian iron trade.

The official tables giving the statistics of the Belgian iron trade for the year 1870, have now appeared, and show that, whilst there has been an increase of no less than 59,480 tons in the importation of iron ore, pig, scrap, and other iron goods, there has, in the same period, been a decline in the exports of similar articles to the extent of 27,222 tons.

The following figures are condensed from the official tables, and will give at a glance the actual state of the trade, as far as exportation and importation are concerned :

	Imported 1870.	Imported 1869.	Increase.
	Tons.	Tons.	Tons.
Iron ore	567,523	551,990	15,633
Pig and scrap iron	83,799	61,599	22,200
Iron gooods (exclusive of minerals)	92,722	71,041	21,681

	Exported 1870.	Exported 1869.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Iron ores	178,562	164,576	13,986	....
Pig and scrap iron	8,232	14,266	....	6,034
Rails	122,926	136,186	....	13,260
Plates	20,705	21,058	....	353
Other rolled iron	75,648	81,631	....	5,983

The exports of iron wire remained, in 1870, stationary, as compared to 1869. The names of the countries to which, in the years 1870 and 1869, the entire exports of Belgian iron of every description (iron ores excepted) were forwarded, and the respective quantities, are as under:—

DESTINATION.	1870.	1869.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Russia	62,755	73,681	....	10,926
Swden and Norway	1,889	733	1,156	....
Denmark	317	649	....	332
Zollverein	57,994	41,685	16,309	....
Hanse Towns	3,654	4,936	....	1,282
Netherlands	28,902	27,760	1,142	....
England	13,318	11,716	1,602	....
France	30,349	40,094	....	9,745
Spain	3,301	480	2,821	....
Italy	7,723	19,807	....	12,084
Switzerland	2,809	4,109	....	1,300
Austria	1,383	1,391	....	8
Roman States	35	28	7	....
Turkey	17,810	29,790	....	11,980
Egypt	1,506	1,389	117	....
United States	11,924	11,669	255	....
Cuba and Porto Rico	2,141	1,101	1,040	....
English Possessions	168	56	112	...
Brazil	594	659	....	65
Rio de la Plata	232	616	....	384
Chili and Peru	588	466	122	....
Miscellaneous	462	326	136	....
Total	249,874	273,141	....	23,267

The attention of the Belgian ironmasters is becoming more and more directed towards the production of steel, and amongst others, the Société de Sclessin have erected works for making steel by the Siemens-Martin process.

Canada.—It would appear from the report of Professor Bell, of the Geological

Survey of Canada, that the iron industry of this country, more especially as regards the exploration and exportation of iron ore, is somewhat reviving and progressing. The well-known Hull iron mines, which had been closed for more than a year, and which produce a fine quality of magnetic ore, have come into the hands of a new company, called the Forsyth Mining Co., by whom they were re-opened in August, last year, and about 3,500 tons of ore of 67 per cent. iron had been extracted before the end of the year. The St. Francis River Ironworks, which smelt bog iron ore, and produce a very tough white iron, much used for the manufacture of the cast railway carriage wheels so commonly employed in North America, have continued in vigorous operation. This class of iron ore is also worked extensively at Mr. Larne's new works, near Three Rivers, and at the St. Maurice works. A new company, with a capital of $500,000, has also been formed, to take over the works of the original Moisie Iron Company. In Belmont, the Cobourg, Peterboro', and Marmora Railway and Mining Company have spent considerable sums in improving railway communication with their mines, at which they employ above 100 men, and shipped ore (magnetic oxide) to the amount of 10,000 tons last year. In 1869, however, the produce was 20,000 tons. Several other mines about this place cannot be worked at present for want of better means of communication. The Chaffey mine and the Matthew's mine, both near Newboro', have sent respectively 3,150 and 4,750 tons of magnetic iron by barges to Kingston, and thence by ship to Cleveland, Ohio; whilst from the Cowan mine, about 12 miles west of Perth, a deposit of rich hematite is being worked, containing an average of 60 per cent. iron, of which about 5,000 tons have been already extracted. The very extensive deposits of iron ore which occur in Canada, to the east shore of Lake Superior, still remain unworked; but now that Canadian iron ores are coming into demand for supplying the United States, it seems probable that these ores also will soon attract attention.

France.—Owing to the war, and the consequent disorganization of everything in this unhappy country, no trustworthy information respecting the actual state of the iron and steel manufacture in France has come to hand, and no official returns of production, etc., have been obtained of later date than those for the first half-year of 1870, given in the last quarterly report.

From the official report published last year, the following figures are taken as showing the production in 1869:

	Metrical Tons.	English Tons.
Pig iron, smelted with charcoal	70,400	
Do. do. do. and coke	34,100	
Do. do. coke	573,650	
Valued at about £5,120,000.—Total, 1869	678,150	equal to 637,494
Do. do. do. 1868	606,695	Do. 566,841
Increase in 1869	71,455	
Wrought iron, produced with charcoal	18,300	
Do. do. do. do. and coke	11,400	
Do. do. do. coke	444,650	
Valued about £8,440,000.—Total 1869	474,350	equal to 466,904
Do. 1868	401,780	Do. 395,471
Increase in 1869	72,570	

The value of the steel production (quantity not given) in 1869, is as follows:

	Francs.
Puddled, hearth, and Bessemer steel	35,976,524
Cementation (blister) steel	2,166,140
Cast steel	12,418,510
Sheet steel	780,600
Total	51,341,774 or, about £ 2,053,600

An interesting scientific description of the great deposits of iron, which occur in the metamorphic crystalline rocks in the sland of Elba, so celebrated for their beautifully crystallized native oxides of iron, and from having been worked from the oldest periods in the metallurgical history of this metal, has lately been pub-

lished by Vom Rath, in the "Zeitsch. d. deutsch. Geolog. Gesellsch." xxii., p. 591.

GERMANY.—According to the official report, which is published in detail in the "Zeitsch. f. d. Berg Hutten un Salinen Wesen. i. d' Preussische Staate," vol. xviii., 1870, the production of iron ore in Prussia was, in 1869, as follows:

	Number of Mines.	Workmen.	Production. Zoll. Centner.	Production. English Tons.
Private establishments	1,142	23,921	55,210,239	2,714.172
Government do.	25	1,269	2,701,150	132,938
Total	1,167	25,190	57,911,389	2,847,110

If arranged geographically, these results are as follows :

MINING DISTRICTS.	Mines.	Workmen.	Zoll. Centner.
Breslau (Silesia)	95	4,564	11,394,823
Halle (Prussian Saxony)	11	87	146,287
Dortmund (Westphalia, Hanover, Rhine)	48	2,765	12,096,996
Bonn (Westphalia, Rhine, Hohenzollern, Hesse-Nassau, Waldeck)	957	17,039	31,012,858
Clausthal (Hanover, Hesse-Nassau)	56	735	3,260,425
	1,167	25,190	57,911,389

And if arranged according to the mineralogical nature of the ores :

	1869, Zoll. Centner.	1868, Zoll. Centner.	Increase.	Decrease.
Bog iron ore	798,744	1,180,789	....	382,045
Brown hematite	24,733,659	21,490,538	3,243,121	....
Spathic carbonate	11,149,117	10,657,837	491,280	....
Clay ironstone	1,212,212	1,661,773	....	449,561
Blackband (Kohleneisenstein)	6,358,884	6,533,840	....	174,996
Hematite (with a little limonite)	10,450,092	10,154,735	295,357	....
Magnetic iron ore	201,709	193,913	7,796	....
Limonite (Bohnerz)	3,007,012	2,372,253	634,759	....
Total	57,911,389	54,245,678	3,665,711	....

The rapid increase in the production of iron ores, since 1855, may be seen from the following figures, which represent the average yearly extraction during the following periods :—

Average from 1855 to 1857. . .20,247,640 Zoll. Centner.
Do. 1858 to 1860. . . .17,677,695 do.
Do. 1861 to 1863. . . .21,309.169 do.
Do. 1864 to 1866. . . .31,224,585 do.
Do. 1867 to 1869. . . .53,205,567 do.

The exact figures for each of the last three years being as follows:—

Year.	Mines Worked.	Men Employed.	Zoll. centner iron ore.	English tons.
1867	1,405	23,094	47,699,639	2,347,379
1868	1,228	23,997	54,245,678	2,669,691
1869	1,167	25,150	57,911,398	2,849,107

With respect to the yield of the blast furnaces, the total quantity of cast iron made in 1869 in the Prussian States amounted to 23,611,587 zoll. centners, or 1,151,945 English tons, against 1,036,713 tons in 1868, or an increase of 11,523 tons over the preceding year. The particulars of production for 1869 are as follow :—

District.	Furnaces.		Smelted by		Coke and Charcoal.	Total Production in Zoll. centners.
	In blast.	Idle.	Coke.	Charcoal.		
Silesia	74	43	4,169,409	511,171	147,265	4,827,845
Brandenburg	1	2	.....	2,618	......	2,618
Saxony (Prussian).	2	2	.....	73,767	......	73.767
Westphalia	53	16	5,593,744	290,410	598,773	6,482,927
Hanover	13	3	2,065,640	51,910	342	2,117,892
Rhine Provinces	19	32	8,506,628	100,881	633,914	9,241,423
Hesse-Nassau	26	4	341,571	497,644	13,756	852,971
Hohenzollern	1	1	......	9,189	......	9,198
Waldeck	1	..	......	2,955	......	2,935
Total 1869	270	103	20,676,992	1.540,545	1,394,050	23,611,587
Do. 1868	264	100	18,577,068	1,600,255	887,876	21,065,199
Difference.	6	3	2,099,924	59,710	506,174	2,546,388

The total make of wrought iron of all descriptions in 1869 amounted to 15,250,059 Zoll. centners, or 747,542 English tons, against 605,831 tons in 1868; thus showing an increase of 141,701 tons.

The particulars of the products for 1869 are (given in Zoll. centners) as follow:—

Provinces.	Bar iron of all sorts.		Total.	Sheet.	Wire.	Total Wrought Iron, Zoll. centner.
	Coke made.	Charcoal made.				
Silesia	2,400,905	57,906	2,458,811	134,524	89,338	2,682,673
Posen	....	3,750	3,750	....	....	3,750
Prussia	52,200	96,546	148,746	....	....	148,746
Pomerania	....	22,464	22,464	....	....	22,464
Brandenburg	160,014	9,300	169,314	31,586	....	200.900
Saxony (Prussian)	54,568	5,985	60,553	4,800	120	65,437
Westphalia	4,847,794	4,756	4,852,550	568,936	661,102	6,082,588
Hanover	49,935	7,735	57,670	14,000	356	72,026
Rhine Provinces	4,595,876	19,551	4,615,427	1,061,773	108,322	5,785,522
Hesse-Nassau	96,467	30,715	127,182	20,236	30	147,448
Hohenzollern	....	11,100	11,100	....	....	11,100
Schlesvig Holstein	....	24,000	24,000	462	....	24,462
Waldeck	2,456	451	2,907	....	....	2,907
Total in 1869	12,260,215	294,259	12,554,474	1,836,317	859,268	15,250,059
Do. 1868	10,115.224	298,938	10,414,162	1,700,276	805,029	12,919,467
Difference	2,144,991	4,679	2,140,312	136,041	54,239	2,320,592

The estimated value of the entire production of cast and wrought iron in the Prussian States for the years 1869 and 1868 are given as under:—

	1869.		1868.	
	Prussian Thalers.	£ Sterling.	Prussian Thalers.	£ Sterling.
Cast iron of all descriptions	43,353,602	6,283,130	37,688,951	5,462,166
Wrought do. do.	59,627,063	8,641,603	52,395,464	7,593,545
	92,980,665	14,924,733	80,083,415	13,055,711

The manufacture of steel is stated to have produced the following quantities in the years 1869 and 1868 respectively :—

Year.	Ordinary Steel Zoll. Centners.	Cast and Bessemer Steel, Zoll. Centners.	Refined Steel. Zoll. Centners.	Total.	
				Zoll. Centners.	English Tons.
1869	792,252	2,055,444	139,623	2,987,319	147,018
1868	583,029	1,764,390	99,735	2,447,154	119,437
Increase	209,223	291,054	39,888	549,165	27,581

In Essen, although the effects of the war have been to increase the demand for certain descriptions of iron, especially those used for fortifications, still the prices have been kept down for the importation of iron from Belgium and Luxembourg, whilst the high prices of coke and want of hands have rendered the cost of the iron nearly as high as its selling price; so that many ironmasters have preferred blowing out their furnaces than making pig without profit. Some of the larger ironworks show an increase of make over 1870, but in the district of Siegen, where, in July last year, 35 furnaces were in blast, at present only 15 are in operation. The rolling mills have suffered more than the rail mills, and the future is considered to look gloomy. Certain brands are considered not likely to recover even after peace is established, and the effects of the war have been to establish the manufacture of spiegeleisen (hitherto almost confined to this district) in Sweden, and more recently in South Wales, at Ebbw Vale. A description is given by Dr. Klüpfel, in the "Berg. u. Huetten-Zeitung," 1871, p. 21, of the mode of occurrence of the iron ores pertaining to the Liassic formation of the Hartz, which have only been utilized during the last 10 years, in the course of which 4 large establishments for their reduction (the Porta, Tuetonia, Helmstädter, and Mathilde Smelting Works) have been erected. They contain 37½ per cent. iron in the wet state in which they come from the mine, or 44 per cent. when dry, along with 8 to 9 per cent. silica, a little more alumina, and from 1 to 2 per cent. carbonate of lime, and are found in very large quantities as regular beds, intercalated like the Cleveland ores between the other strata. In the same journal, a resumé of the different iron ores of the Clausthal district, in Hanover, gives their geological occurrence as follows:—In the Devonian limestones, beds and patches of brown hematite, and beds of both brown and red hematite; in the coal formation, veins of red hematite; in the magnesian limestone, mosses and patches of brown hematite, and spathic carbonate of iron; in the lias, beds of brown hematite and clay ironstone; in the chalk formation, beds of limonite (Bohnerz), which also occur along with beds of scoriaceous brown hematite, and patches and thin seams of silicious limonite in the middle Tertiary series, whilst bog iron ore is found in the alluvial deposits.

A volume containing a series of 10 working drawings of the ironworks at Kreuzthal, near Siegen, in Prussia, with details of the erections, blast furnaces, blowing machines, etc., has recently been published by Messrs. Hupfield & Schermeng, entitled "Hohofen-Anlage des Cöln-Musener Bergwerks-Aktien-Vereins in Kreuzthal, bei Siegen, Halle, Knapp I."

As regards South Germany, the official returns for 1869 show that in that year, 208 iron mines were in work, which employed 720 men, and produced 212,030 tons of iron ore, being an advance of 15½ per cent. upon 1868; the average production of iron ore in the 10 years from 1858 to 1868 amounted to 147,722 tons annually. Wrought iron made in 1869 was 127,226 tons, along with 400 tons steel. From Saxony we have as yet only returns for 1868, in which year 80 iron mines were worked by 445 men, and yielded 19,506 tons of ore, whilst the produce of the iron furnaces and steel manufacture only amounted to 19,812 tons of cast iron of all descriptions, 18,101 tons bar iron, 107 tons sheet, and 103 tons of steel.

Poland.—This country being destitute of coal, all the iron produced is smelted with charcoal, and, as in all countries similarly situated, the make of the Polish ironworks, never very great, is declining, owing to the diminution and destruction of the forests, and the increasing price of fuel. So very little being known concerning the iron production of Poland, it may not be uninteresting to give the following statement, kindly furnished by M. W. Rau, of Warsaw, which shows the present annual make of charcoal pig iron in centners, and the names and number of blast furnaces, now in operation, at the private ironworks in that country:—

Name.	Blast Furnaces.	Production. Centner.
Chlewisk	2	50,000
Przysucha	1	20,000
Drzewice	1	30,000
Krasny	2	40,000
Falków	1	20,000
Klimkiewiczow	2	60,000
Inowlodz	1	20,000
R. Bialoczew	1	15,000
Konskie	2	50,000
Rzucow	1	15,000
Noików	1	15,000
Boruchow	1	20,000
Korytkow	1	20,000
Machory	1	20,000
Chmielów	1	15,000
Borkowice	2	40,000
Szczesno	1	15,000
Blachownia	2	40,000
Kradzionów	1	30,000
Maleniec	2	50,000
Gustek	1	20,000
Poremba	1	20,000
Truskolas	1	20,000
Mijakow	1	20,000

In all, 31 blast furnaces, which, from their small size, make only a total of 655,000 centners, or 32,728 English tons per annum, the make of each furnace varying from 750 to 1,500 tons yearly. Besides the above, there are some few furnaces which have lately come into the hands of a Russian company; and also, at Dabrowa, near the Prussian-Austrian frontier, the returns from which, although promised, have not as yet come to hand.

Sweden.—According to the Berggeist, the celebrated iron mines of Gellivara, in the North of Sweden, which were for some time worked by an English company, have now been stopped, principally on account of the great severity of the climate and the difficulties arising from want of communication and transport.

The construction of the Swedish Central Railway, now being made by an English company, which is proceeding rapidly (the first section from Frövi to Linda is to be opened in July, 1871), will bring the celebrated iron mines of Westmanland into direct railway connection with the port of Gottenburg, on the North Sea, and will, it is expected, thereby enable iron ores of 60 per cent., and great purity, to be exported and delivered on the east coast of England, at about 20s. per ton.

A memoir on the iron metallurgy of Sweden has been published in German by the eminent Austrian metallurgist, P. Tunner, entitled " Das Eisenhüttenwesen in Schweden. mit Holzsch u. 6 Tafeln. gr. 8 vo. Leipzig, Felix."

United States.—Large deposits of aluminous brown hematite, containing 37 per cent. iron, with traces only of phosphoric acid, have been met with in Coshocton and Licking counties, Ohio. Considerable quantities of ore have been smelted with, it is stated, good results, in the charcoal furnaces along the Pittsburg and St. Louis line.

Professor Winshall has also communicated, at the meeting of the American Association, a description of immense beds of hydrated oxide of iron or bog ore, covering several townships, and said to be of unknown thickness and of great purity. These deposits are situated in the upper peninsula of Michigan, on the tributaries of the Monastique river, down which they can be floated to Lake Michigan. They lie in the direct track of the projected railroad intended to connect the North Pacific Railroad with the railway system of Michigan, and are regarded as of great value for mixing with the iron ores of the Lake Superior district ; regarding which latter ores the furnace proprietors in Western Pennsylvania have held a meeting at Sharon, to make arrangements with the mines and railways for obtaining them at lower rates, as their present high prices tell greatly against them now that the duties on foreign iron have been lowered by the new tariff.

In the year 1869 no less than 65 new blast furnaces were built in the United States, and it is estimated that the iron production of the country gives direct employment to 140,000 workmen, besides some 800,000 more required for the further manufacture of the iron and steel

so produced. In the "Berg. u. Huetten Zeitung," for January, February, and March, 1871, a series of communications by Dr. Gustav Klüpfel, on the "Iron Metallurgy of the United States," will be found. They are illustrated, and contain many useful data concerning the actual condition of the iron manufacture in this country.

B. *Metallurgical Technology.*

Smelting Iron Ores.—The trial of an entirely new style of furnace for reducing iron ores to cast iron is reported from Omaha, in the United States. It would appear from the very imperfect description as yet received, that the furnace employed is a sort of cupola, 25 ft. in height and 5 ft. in diameter, tapering towards the top. About half-way up the outside of the furnace is a steam pipe which encircles it, and from which 12 jets of steam blow off into the interior of the furnace, thereby producing a vacuum, and, consequently, drawing in a strong current of air from below, which does away with the necessity of having any blowing machine. This furnace is intended for smelting the iron ores of the large deposits, situated at Blackhills, near the highest level of the Union Pacific Railway, which that Company propose to utilize for the supply of iron for their foundry and workshops. This furnace is the invention of a Mr. Faucett, and, after a fortnight's trial, is reported to have worked so satisfactorily and economically that others are proposed to be built at once.

Chemistry of the Blast Furnace.—Mr. Lowthian Bell's work on the "Chemical Phenomena of Iron Smelting," has recently been translated into German, and published at Leipzig, by the eminent Austrian metallurgist, P. Tunner. The translation has been most favorably received and reviewed. Three papers on the "Chemistry of the Smelting of Cast Iron," by Herr C. Schinz, have appeared in Dingler's "Polytechnische Journal," for January and February, 1871; but as it is stated, in a foot note, that the substance of these communications has already appeared in England as an appendix to the English translation of Schinz's "Researches on the Action of the Blast Furnace," 1870, we must refer to that volume for their contents.

Blast.—A notice of Gjers's hot blast stove is given by P. Tunner, in the "Zeitsche. Berg. u. Huetten v. f. Kärnthen," 1871, p. 30, and some remarks by C. Schinz on Siemens' pyrometer, described in the first number of the "Journal of the Institute," are to be found in Dingler's "Polytechnische Journal," cxcviii., p. 394, in which he expresses an unfavorable opinion as to its accuracy, based on the belief that the electric relations will not continue the same in proportion to the increase in the temperature to be measured.

Root's (so-called) American blower, so far from being either a new or an American invention, is quite identical in principle with one long in use in England. Amongst others then employed in the Midland counties, one of these blowing machines was examined by the author (D. F.) in 1846, at Messrs. Elkington & Mason's Works in Birmingham.

Desulphuration of Coke.—An important paper on this subject, by M. Philippart, which has received the premium, and contains a summary of the different processes hitherto employed, is to be found in the "Revue Universelle des Mines," 1870, p. 315.

Puddling.—In the "Preussischer Zeitschr. f. Berg. Huetten u. Salinenwesen," 1870, p. 145, will be found an extremely interesting paper by Dr. Kosmann, in which he gives the results of a comparison between the effects and relative economy of puddling in the ordinary manner, and when done by Siemens' regenerative gas puddling furnace; although short, the space at command will only allow of our giving the conclusions arrived at, which are (1), that the Siemens furnace is to be preferred in all cases where an extremely high heat is required, and where the fuel is of bad quality and unsuited for producing sufficient heat when consumed in the ordinary way; (2) whenever a fixed temperature or a certain quality of flame is required for any length of time; (3) when no use of the waste heat of the flame (as for heating steam boilers to drive machinery) is required. And, in addition, there is less waste and also somewhat less loss of iron in the slag with the Siemens than with the ordinary furnace, as may be seen by a comparison of the chemical analysis of the respective slags.

	Ordinary Furnace.	Siemens Furnace.
Silica	11.98	15.36
Alumina	1.11	1.18
Protoxide of iron	68 69	66.33
Do. manganese	1.00	0 92
Lime	1.79	2.51
Magnesia	0.24	0.92
Soda and potash	2.13	0.72
Phosphoric acid	14.43	14.28
Sulphur	0 24	0.28
Total	101.61	102.50

The amount of phosphorus or sulphur eliminated in the slag is about the same in both instances. If, however, the fuel is of good quality, and the waste heat is employed for raising steam, then there appears to be little, if any, advantage in the employment of the Siemens furnace, which is known to be extremely costly, both in original construction and in subsequent repairs.

Purification of Iron and Steel.—In the last quarterly report, the Sherman process, then being tried at Pittsburg, in the United States, was briefly alluded to; but as the complete specification of the British patent, which the inventor had applied for, July 25th, 1870, No. 2,092, had not then been made public, the substance employed by him to effect the supposed purification was not at that time known.

It now appears that the claim made in this patent is for the use of iodine, or its compounds, to purify and eliminate phosphorus and sulphur from iron and steel. Quite independent, however, of the highly improbable supposition, that the addition of a small quantity of so extremely volatile a substance as iodine could effect such results as are claimed, it seems absolutely impossible that any such agent could be brought into actual contact with the whole of even the minute quantity of phosphorus or sulphur disseminated throughout all parts of so large a mass of iron, which, according to the rationale of this invention, it must necessarily do, in order to combine with the whole of these elements to carry them off. Lately, however, experiments on the large scale have been carried out in this country, and although the results are as yet not generally known, it is understood that they have decided conlusively against the claims of this process.

Another process for the attainment of the same objects, and very analogous in character to the above-mentioned, has still more recently been brought prominently forward in the United States, where it is called the Henderson process, also from the name of its inventor.

In an exposition of the main features of this method for refining iron, and for the production of steel and wrought iron, New York, December 15, 1870, the inventor, Mr. James Henderson, states that:—"The novelty of this invention consists in the employment of fluorine combined with oxygen. Fluorine is a more powerful agent than oxygen for the removal of silicon, and removes the silicon and the greater part of the phosphorus within 5 minutes of the beginning of the chemical reactions in the refining process. The sulphur and carbon are next acted upon and removed in the order in which they are named. The fluorine and oxygen are so combined as to insure simultaneous action upon the iron. The best results are obtained when oxygen, fluorine, and titanium or titanic acid are combined."

In this process, fluorspar, which is the fluoride of calcium (or other fluorides), is used as a source of fluorine, whilst the native oxides of iron (or other oxides), preferably those containing titanium are employed to supply the oxygen. In applying this system to the refining of the pig iron as it is tapped from the blast furnace, the mode of working is as follows: Cast-iron moulds or "chills" are prepared by having a mixture of 1 part fluorspar with 3 parts by weight of the iron ore, spread over their bottoms to a depth of from $\frac{1}{4}$ to $\frac{3}{8}$ of an in. (both of these substances having been intimately mixed with one another after having been powdered so finely as to have passed through a sieve of 400 meshes to the inch; the iron is then run into the chills so as to form slabs about 1 in. thick. What takes place may be described in Mr. Henderson's words:—"The heat of the iron causes fluorine and oxygen to be liberated, and by reason of the affinities of these substances for silicon and phosphorus, the impurities are removed in the form of vapor. The reactions in the chills are similar to those of the boiling puddling process, and last about 5 min.

The metal during this period is covered with jets of flame and smoke. The resulting metal, with respect to silicon and phosphorus, is as pure as wrought iron." The following analyses are given to show the composition of ordinary coke pig iron, made near Pittsburg, U. S., from a mixture of hematite with mill cinder, and of the refined cast iron and bar made from it by this patent process :—

	Pittsburg coke, pig.	Refined cast iron.	Bar Iron.
Carbon, combined	0.2040	0.3613	Not determined.
Do. graphitic	2.7685	2.5066	Do.
Silicon	2.3096	......	....
Slag	0 3623	0 1983	Not determined.
Phosphorus	0.4196	0.1029	0.0087
Sulphur	0 1298	0.1269	0.0438

Whether these results will be confirmed by subsequent working on the large scale remains to be demonstrated, but at present Mr. Henderson sums up the advantages likely to ensue in the manufacture of bar iron from the use of his process as follows : (1.) Better quality, due to the purity of the refined pig, equal to wrought iron made from the best ores smelted with charcoal. (2.) The refined metal, being as free from sulphur and phosphorus as wrought iron itself, requires only decarbonizing, less skill to work it, and affords a more certain quality of product. (3.) Large saving in the cost of production, owing to the shortening of the time in puddling. (4.) Saving of nearly ½ the fuel per ton of iron. (5.) Reduction of general expenses to ½, owing to increased production. (6.) Reduction of 40 per cent. in wages per ton of iron by reason of diminished labor. (7.) The puddling furnace cinders contain but ¼ the ordinary quantity of phosphorus, and when smelted produce better iron.

A modification of this process, for the production of steel or wrought iron, is carried out in a reverberatory furnace, lined with the mixture of pulverized fluorspar and iron ore, preferably titaniferous, the cast iron as it is, or which has been previously refined in the chills as before described, being melted down and kept in the liquid state until, first, the whole of the phosphorus and sulphur, and subsequently the carbon, is removed; no stirring or labor is said to be required, the metal being tapped or balled according to the length of time, or as steel or wrought iron is required. An analysis of the steel made on the large scale at Pittsburg, U. S., by this process showing no trace of silicon or phosphorus, and only a trace of sulphur, is appended, but is of no value for comparison, since no analysis is given of the original pig iron from which they had been attained. Of this process, Mr. Henderson writes : "The refined iron is purer than is possible to be obtained in the pig mould-process, for the reason that the iron is kept fluid, and the reactions continue until all the slags or silicates, phosphorus and sulphur, are removed, so as to produce cast iron alloyed only with carbon; and the carbon may be progressively diminished to form high, medium, or low steel, or all be removed to form wrought iron in one operation, and these results are obtained without the labor of puddling or stirring the metal during the conversion ; the only labor required is 'balling' the steel or wrought iron, when the conversion is conducted in furnaces, wherein the temperature is not high enough to keep the metal liquid enough to be run from it."

Manufacture of Steel.—M. Aristide Berard has recently introduced into practical operation, at Givors, in France, a process for the direct conversion of pig iron into steel, for which, among other advantages, he claims that it effects a partial purification of the iron, by eliminating the sulphur, phosphorus, arsenic, etc. ; at least, to such an extent, that commoner brands of pig iron, which by no process at present known could be used, may be employed for making steel suitable for the manufacture of rails, tyres, etc. ; and that, by the combined action of air and gas, alternate oxidizing or reducing effects may be obtained at pleasure, so that the decarbonization

or recarbonization, and consequent uniform nature of the product, may be regulated, whilst, at the same time, the waste is reduced to a minimum. The main feature of the process is—the conversion of the fuel employed into a gaseous state, the use of a jet of superheated steam in so doing, and in the employment of a peculiarly-shaped converting furnace, in which from 3 to 5 tons of cast iron is treated at a time, the charge being run into the movable bed of the furnace, in the molten state, direct from the blast furnace or cupola. Spiegeleisen is added in the operation, and the waste is stated to be not more than from 7 to 8 per cent., whilst the operation is said to require only from 1 hour to 1½. The process has been fully described in a pamphlet, published by M. Berard; but as it would occupy too much of our space to give a detailed account of it, we may refer to a description, illustrated by figures, which has lately appeared in the "Engineer" of April 7th, 1871, where full particulars will be found.

Bessemer Steel.—In this manufacture, A. Brunner, in a communication, published in the "Oesterreich. Zeitsch. f. Berg. u. Huetten Wesen," February 20th, 1871, p. 59, advocates a combination of the Siemens-Martin process with the use of the Bessemer converter. The former process would only be used by him so far as to make a homogeneous quality of refined iron, which, after being brought to a high heat in the Siemens furnace, is tapped directly into the Bessemer converter, and blown as usual. By such means he considers that it would not be necessary to keep to certain brands of pig only for making such steel, but that all the less uniform quality of iron, at present unsuited for the manufacture of Bessemer steel, could be brought up to an uniform quality before being treated in the converter.

The slag produced in the Bessemer converter at Hörde has been examined by H. Scheerer, both chemically and crystallographically, the crystals being found in the centre of the bricks of slag which are produced by allowing the slag which remains behind in the converter, after the steel is poured, to run into a mould and consolidate. The analysis showed the slag to consist of :—

Silica	44 73
Protoxide of iron	20.59
Do. manganese	32 74
Lime	1.53
Magnesia	0.17
	99.76

As the ratio of the oxygen in the acid is to that of the bases as 23.85 to 12.43, or nearly double, the slag is evidently a bisilicate. The specific gravity was found to be 3.08, and the crystalline form triclinic, the angles closely approaching those of paisbergite, which is a native bisilicate of manganese, with a little lime and iron.

Classification of Bessemer Steel.—From a paper by E. F. Durre, of Berlin, in the "Preuss. Zeitsch. f. Berg. Huetten. u. Salinenwesen," on the Bessemer steel works of Seraing in Belgium, where this steel is made from Cumberland hematite pig, with an admixture of spiegeleisen, we extract the following observations. The steel from the converter is sorted into 3 classes, each of which is in turn subdivided according to hardness, as follows :

I. Absolute cohesion, 48 to 56 kilogrammes per square millimetre. Permanent extension, 20 to 25 per cent. Can be welded but not tempered	(*a*) Called "extra soft," contains less than from 0.25 to 0.35 per cent. carbon; is used for arms, artillery, boiler plate and sheet, rivets, etc.
II. Absolute cohesion, 56 to 69 kilogrammes per square millimetre. Permanent extension, 10 to 20 per cent. Welds badly, and tempers badly	(*b*) Called "soft;" contains less than from 0.35 to 0.45 per cent. carbon; is used for machinery, tyres, axles, rails, etc. (*c*) Called "half soft," or "half hard;" contains 0.45 to 0 55 per cent. carbon; is used for tyres, rails, pistons, and parts of machines exposed to friction.
III. Absolute cohesion, 69 to 105 kilogrammes per square millimetre. Permanent extension, 5 to 10 per cent. Will not weld, but tempers well	(*d*) Called "hard;" contains from 0.55 to 0 65 per cent. carbon; is used for springs, cutting tools, files, saws, drills, and miners' tools, etc. (*e*) Called "very hard;" contains about 0.65 per cent. carbon; is used for fine springs and tools, spindles for weaving, etc.

In order to determine the class in this scale to which the steel belongs, three tests, respectively physical, mechanical, and chemical, are made use of.

1. *Physical.*—Only by the eye; the fracture and grain or texture of the steel being to the practised eye sufficient to enable it to be at once referred to one of these five classes; but, if not, a trial of its temper will at once settle the question.

2. *Mechanical.*—By bending under the hammer; class (*a*), at Seraing, admits of being bent U shape without breaking; or even, by repeated blows, allows both ends of the U to be closed together without fracture; whilst, on the other hand, the steel of class (*e*) breaks the moment the angle of bending reaches from 130 to 140 deg. Between these two extremes it is easy to arrange the others, on the basis that the hardness of a steel is proportionate to the angle at which it breaks when bent. These daily tests are occasionally checked by an actual determination of the actual cohesion and extension of the steel.

3. *Chemical.*—By determining the quantity of carbon in the steel. By a modification of the Eggertz coloration tests, this can be done in less than 2 hours, as follows: Two portions of the steel, in the shape of borings, each weighing 0.2 gramme, are dissolved in 20 cubic centimetres nitric acid of specific gravity 1.2, and heated to 80 deg. C. in a water bath. At the same time, two other similar trials are made each day with two steels containing different but known amounts of carbon (say, for example, 0.61 and 0.63 per cent. of carbon, always choosing samples with considerable carbon), so that these standard test solutions are always at hand for comparison. All the solutions are then placed in equally wide glasses, and brought to the shade of color of the standard test solution, by the addition of water, after which the volume of the solutions as compared with that of the standard test solutions, will enable the amount of carbon present to be calculated to within 0.03 percentage.

Strength of Steel.—In connection with steel it may not be devoid of interest to give a statement of the tests fixed for the strength of the cast steel work to be employed in construction of the great bridge over the Mississippi. The specification runs as follows:

"The steel shall be of the kind known in commerce as crucible cast steel. It will be required to stand the following tests, and failure to stand any one of such tests will be sufficient cause for the rejection of the piece. The staves comprising the tubes will be required to stand a compressive strain of 60,000 lbs., and a tensile strain of 40,000 lbs. per sq. in. of section without permanent set.

"They must stand a tensile strain of 100,000 lbs. per sq. in. without fracture. The modulus of elasticity shall not be less than 26,000,000, nor more than 30,000,000 lbs. This variation shall be avoided if possible, in which case the lower amount will be preferable. If a variation occurs in the modulus, bars having the same modulus must be selected in making up the tubes, so that one side of the tube shall not have greater power of resistance than the opposite one. Those having the same modulus shall be placed in the same tube. Each bar will be tested by the contractors, and the modulus stamped on it by the Illinois and St. Louis Bridge Company's inspector.

"The steel pins will be required to stand without permanent set a tensile strain of 40,000 lbs. per sq. in., and an ultimate tensile strain without fracture of 100,000 lbs. As it will be inconvenient to test these pieces, the engineer will require to have 2 or more of them made in one piece, and of sufficient length, cut from the middle or ends of the piece, a sample for testing. In such cases, failure of the sample will cause the rejection of the entire piece.

"Rods, bolts, eye-washers, rivets, etc., will be required to bear an ultimate tensile strain of 100,000 lbs. per sq. in. without fracture, and 40,000 lbs. per. sq. in. without permanent set. Such parts of the work will not be tested in tension beyond 40,000 lbs., sample pieces only being subjected to ultimate tests. Such tests as, in the judgment of the engineer or inspector, may be necessary to detect flaws or other imperfections, when the pieces cannot be conveniently subjected to trial in the testing machine, may be used, and any flaw or other imperfection existing in any piece will be sufficient cause for its rejection, if in the opinion of the engineer or inspector it is injured thereby.

"The ¼-in. plate steel for enveloping the

staves will be required to have a resistance to compression and tension without set equal to 40,000 lbs. per sq. in., and an ultimate tensile strength of 100,000 lbs."

CHEMICAL ANALYSIS.—Amongst the new works on chemical analysis specially devoted to the subject of the metallurgy of iron and steel, one has been recently published in French, entitled "Manuel pratique d'Analyse chimique appliquée à l'industrie du fer. Par MM. de Koninck et Dietz, 1 vol. 12mo. avec planche. Paris et Liége. Baudry 4 fr." Not having as yet received the book, we are not able to criticise its contents; its title, however, promises to supply a desideratum.

In Sweden, Prof. Eggertz, of Fahlun, so well known in connection with the chemical examination of everything connected with iron and steel, has recently published a work, "Om Kemisk profning af jern, etc., Fahlun, 1871," being instructions for the chemical analysis of iron ores, iron, steel, and fuel. This work cannot be too highly commended, but, unfortunately, until it is translated into English, it is to be feared that its being written in the Swedish language will make it inaccessible to most chemists or others interested in the subject.

The volumetrical determination of iron by means of hyposulphite of sodium, has lately been experimentally investigated by Oudemans, whose results, given in Frezenius's "Zeitsch, f. Analytische Chemie," 1871, p. 343, show that this process yields more accurate results when slightly modified by adding, in the first instance, a small excess of hyposulphite, and then, after determining the amount of this excess by titrating with a $\frac{1}{10}$ standard solution of iodine, deducting it, so as to get the true amount of hyposulphite used more correctly than by measuring it directly, as is usual.

The estimation of the total carbon in cast iron is recommended by Dr. Wittstein ("Polytech. Journal," Nov., 1870), to be conducted as follows:—About 1.25 gramme of the iron, in coarse powder, is placed in a flask already containing 50 gms. water, 10 gms. chloride of sodium, and 10 gms. sulphate of copper, and left for a couple of days in this solution; 10 gms. hydrochloric acid of Sp. Gr. 1.13 are then added, and the whole heated on a sand bath, by which the hydrated oxide of iron and finally divided metallic copper are dissolved, and after the liquid has been diluted with twice its bulk of water the carbonaceous matter remaining undissolved may be collected on a filter, which has previously been dried at 212 deg. Fahr., and weighed. After drying at 212 deg. Fahr. and weighing, the filter, with carbon, may be incinerated, when the amount of carbon will be found by subtracting the weight of the residue; traces of carbon sometimes remain with the ashes, as also a small quantity of copper and iron.

DETERMINATION OF SULPHUR IN CAST IRON.—Gintl ("Polytech. Journal cxc.," p. 113) treats the iron with perchloride of iron, until it is as far as possible dissolved, after which the insoluble residue of carbon, sulphur, phosphorus, silicon, etc., is fused with a mixture of nitrate of potassium and caustic potash. All soluble matter is dissolved out of the fused mass with water, and to the filtered solution previously rendered acid by hydrochloric acid, chloride of barium is added, in order to precipitate the sulphuric acid as sulphate of barium, from the weight of which the sulphur present in the iron may be calculated.

In order to determine the amount of phosphorus in iron or steel, Belain "(Oesterreichische Zeitsch, f. Berg. u. Huetten," 1870, No. 33) recommends the iron to be dissolved in nitric acid, evaporated to dryness and the residue fused with carbonate of potassium or sodium; the fused mass must then be digested with water and filtered, when the phosphoric acid in the filtrate may be estimated by tituration with a standard solution of acetate of uranium, ferrocyanide of potassium being employed to indicate the end of the reaction, as this salt produces a brown cyanide of uranium when the reagent is in excess.

Kessler also describes in the "Journal, f. Prakt. Chemie," 1870, p. 364, a process he has devised for the determination of phosphorus in iron or steel, which consists in first removing the whole of the iron from its solution, by precipitation with ferrocyanide of potassium and subsequently precipitating the phosphoric acid remaining in the filtrate as phosphate of ammonia and magnesia as usual. As this paper, has, however, been translated in full in the "Chemical News," for February 17, 1871, this latter journal may

be referred to for particulars of the process.

In connection with the determination of phosphoric acid by the molybdate of ammonia process, Dr. Richter, in a paper in the "Polytechnische Journal," has shown that this precipitation is much interfered with by the presence of much sulphates or nitrates in the solution, so much so that if but very little phosphoric acid is present its precipitation may be altogether prevented; as a means of counteracting this source of error he finds that the addition of an excess of nitrate of ammonia to such solutions is sufficient to insure the precipitation of the yellow molybdo-phosphate of ammonia. Dr. Richter has also examined the yellow compound of silicic acid with molybdic acid, and finds that the presence of silica in solutions gives with the molybdate a yellow coloration like that produced from phosphoric acid, but that it only deposits after a very long time; this precipitate, although not immediately dissolved in ammonia as the phospho-molybdate is, does gradually dissolve, and when the magnesian salt is added it precipitates a silicate of magnesia which he thinks has often been confounded with the ordinary phosphate of magnesia and ammonia, and may thus have led to considerable errors in the determination of phosphorus in iron and its ores, etc.

Iron Deposited Galvanically.—The extreme difficulty of obtaining chemically pure iron, for the purpose of studying its properties, led to the attempts to precipitate it from its solutions by galvanic action, which is easily done by employing a weak battery and a solution of sulphate of iron, mixed with sulphate of magnesia; having, at the same time, sufficient carbonate of magnesia in the solution to keep it constantly neutral in proportion as the iron is reduced. Thus obtained, the iron presents itself as a fine-grained deposit, in which no trace of crystallization can be seen under the microscope. Its color is a soft light gray, and its hardness is so surprisingly great, that it can only be scratched with a file; it being at the same time so brittle, that a piece of $\frac{1}{8}$ of an inch thick can easily be broken between the fingers. These properties, however, at once change upon heating the iron; it then becomes very much softer, and as malleable as it was before brittle, and can be cut with the scissors with the greatest ease, as well as bent to and fro numerous times without breaking. Iron so deposited was, until lately, supposed to be pure iron, but the researches of the late Professor Graham on the occlusion of gases in metals caused Professor Jacobi to examine it more carefully "(Bulletin de l'Academie des Sciences de St. Petersburgh," xiv., p. 292), when he found that it in reality contained a considerable amount of hydrogen gas. Still more recently, this iron has been investigated by R. Lenz, "Annales des Physik. u. Chemie, Erganz." Bd. V., p. 242, whose results are of great interest, and are likely to throw some light on the subject of the absorption of gases by iron. He finds that all such electro-deposited iron contains very much hydrogen, with more or less carbonic acid, carbonic oxide, nitrogen, and water, and that it may have occluded in its substance as much even as 185 times its own bulk of these gases (principally hydrogen), which are evolved again on the application of heat. When heated out of contact with the air or oxidizing matters, this iron changes color, and becomes of a color exactly resembling platinum; and if now placed in water, a portion of the iron is oxidized at the expense of the oxygen in the water, whilst the hydrogen set free is at once absorbed, or again occluded by the rest of the iron.

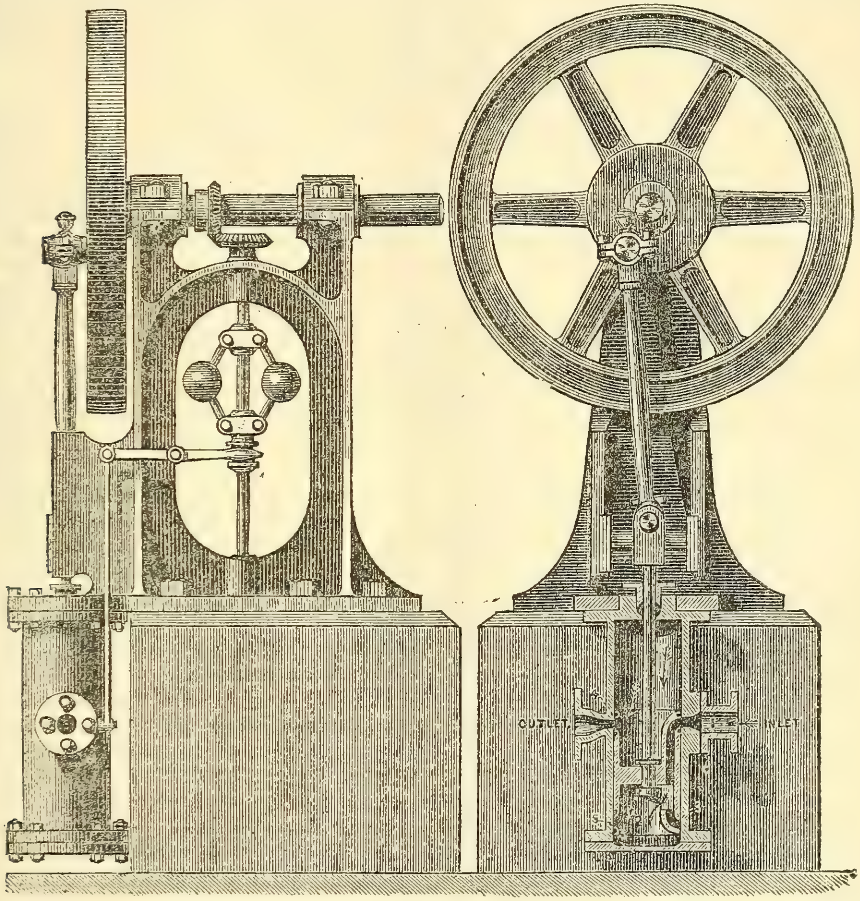
The metropolitan police report that the tramways already made facilitate traffic and cause no obstruction, except at a terminus, as at the foot of Westminster Bridge. But they have not yet been tried in the more crowded streets; that experiment has yet to be made. Under the circumstances the Board of Trade are unable to lay before Parliament a complete and perfect scheme for tramways in the metropolis.

It is now, we understand, determined to exhibit the electric light to denote the night sittings of the Houses of Parliament on the summit of the Victoria Tower, instead of the Clock Tower, and the necessary machinery is in course of construction, under the direction of Captain Galton, of the Engineers.

KING'S "VALVELESS" ENGINE.

From "Engineering."

Amongst the exhibits at the recent Conversazione of the Institution of Civil Engineers, which we are enabled to illustrate this week, is the valveless steam engine, of which engravings are annexed. This engine is one designed by Mr. H. J. H. King, of the firm of Messrs. H. J. H. King & Co., of St. James's Works, Glasgow, and its construction will be readily understood from the annexed section.



The piston, it will be noticed, is made very deep, and has 4 ports formed in it, 2 on each side. Of the 2 upper ports, one communicates with the cylinder above the piston, while the other forms the mouth of a passage leading to the under side of the piston, as shown. In the same way, of the 2 lower ports 1 leads to the lower end of the cylinder direct, while the other communicates with a passage leading to the upper side of the piston. The cylinder, also, has 2 ports formed in it opposite each other at the middle of its length, 1 of these being the inlet and the other the outlet port.

Supposing the piston to be at the bottom of its stroke, in the position shown in the section, the action will be as follows: The steam enters by the inlet pipe, 1, and passes down the passage cast in the piston, filling the cavity, 2, in the latter, and the clearance at the bottom of the cylinder. This admission of steam causes the piston to rise, when, with the proportions shown, the steam will be cut off at about $\frac{1}{8}$th of the stroke, the steam then expanding

until at about $\frac{13}{16}$ths of the stroke, the bottom port, 5, in the piston begins to open to the outlet pipe and the exhaust commences. A little later, at about $\frac{7}{8}$ths of the stroke, the lower piston port, 3, begins to open to the inlet pipe, and steam is thus admitted to the upper end of the cylinder, causing the piston to perform its downward stroke. The exhaust ports are made sufficiently large to reduce the steam pressure in the cylinder to very little above that of the atmosphere before they close, the remaining steam being then compressed and assisting to fill the clearance spaces. In making high-pressure engines on this plan to run with a piston speed of 200 ft. per min., or upwards, Messrs. King & Co. make the width of the steam ports equal to about $\frac{1}{8}$th, and that of the exhaust ports equal to about $\frac{3}{16}$ths of the stroke; but, owing to the variation of piston speed at different parts of the stroke produced by the crank motion, each steam port will be open for about 44 per cent., and each exhaust port for about 52 per cent. of the *time* occupied by each revolution.

It may at first sight appear that an engine constructed on the plan above described must necessarily be a very wasteful steam user; but a little consideration will show that this need not be the case, particularly if the cylinder be steam jacketed. Its good performance will, however, depend greatly upon the capacity of the clearance spaces and the point of closure of the exhaust being properly adapted to each other, and to the pressure of steam with which the engine is to be worked. Speaking roughly, the most economical performance, as far as the consumption of steam is concerned, will be obtained when the ratio of compression is such, that if no steam was to enter through the supply port, the steam enclosed in that cylinder would attain the boiler pressure at the termination of the stroke. In this case, the steam used per stroke would equal that required to fill a length of the cylinder equal to the width of the supply port, and the work done per stroke would be approximately the same as that which would be developed by the same quantity of steam used in a cylinder without clearance and expanded the same number of times as in Messrs. King's engine. The principal effect of the early closure of the exhaust port during the exhaust stroke which takes place in Messrs. King's engine, is to reduce the power which it is possible to develop in a cylinder of given size. The greater part of the power expended in compressing the steam during the exhaust stroke, is given out again during the steam stroke, the precise proportion between the power absorbed and that regained depending, as we have explained on former occasions, upon the relative ratios of compression and of expansion during the exhaust and steam strokes.

Messrs. H. J. H. King & Co. inform us that the non-condensing engines constructed on the plans shown in our engraving, are found to compare favorably as regards economy, with ordinary non-condensing engines having single slides cutting off at about $\frac{5}{8}$ths or $\frac{3}{4}$ths of the stroke, a class of engine of which so many are now made for various purposes; while they have the advantage as compared with these engines of having no slide valve, eccentric, valve spindle, or valve spindle stuffing box, and they are, moreover, capable of running in either direction. When applied to steam cranes, therefore, small pipes, with cocks for admitting steam to either the top or bottom of the cylinder for starting, replace the ordinary link motion with a very considerable saving of cost. Messrs. King state that the arrangement we have described will give better comparative results with condensing than with non-condensing engines, and if the proportions are properly chosen, there is good reason for supposing that this will be the case. In large engines means are provided for varying the amount of clearance at will, and the ports instead of being cut completely through the cylinder consist of a number of small holes, over which the piston rings pass easily. Altogether the engine is a very simple and ingenious one, and we shall be glad to hear further particulars of its performance upon a large scale.

Reports have been received from the United States expedition which is exploring the Tehuantepec Isthmus in Mexico, to discover a canal route between the oceans, that a practical route has been discovered. No particulars have yet been obtained, however

ACCIDENTS TO RAILWAY STRUCTURES.*

Railway accidents may be roughly classified as follows :

I.—*Running off the track* from breakage of parts of engines or cars ; breakage or displacement of rails ; malicious or accidental obstructions on track.

II.—*Collisions* from disregard or misunderstanding of signals ; overcrowding from badly arranged time-tables ; misplaced switches ; accident to train on one track throwing it in the way of train on the other.

III.—*Failure of structures* from decay or original bad design ; shocks from breakage of machinery, causing trains to run off track while crossing, or from collisions on bridge.

It has been observed that the most disastrous accidents have resulted from an unforeseen combination of two or more of the above causes.

The late appalling accident on the Hudson River Railway is an illustration of this, as it was a combination of all three of the above principal causes.

The primary cause was the breaking of the axle under the oil car.

According to the evidence of Mr. Toucey, Superintendent of the Railway, broken axles have been known to run 20 miles before being discovered, "the frozen ground keeping it up; in this case it evidently dropped through the bridge."

The second cause, therefore, was failure of a structure from shock caused by breakage of machinery. This threw the car from one track over upon the other, and a collision resulted, aggravated in its consequences by the presence of petroleum, and from its being upon a wooden structure, which quickly burned down.

Much severe criticism has been passed upon the Company because "the safety signal," as it is said, "lured the train to destruction."

It appears to have been overlooked that the same unhappy result would have followed if the signal-lamp had been entirely removed, when winter changed the bridge from a movable draw into a fixed structure.

Moreover, a collision would have taken place on a fixed bridge where there never was any signal, if the broken car had happened to have crossed one. In fairness to the employees of the railway, the accident should not be attributed to a disregard or misunderstanding of signals.

The combination of a broken axle, a bridge, a car laden with petroleum, and an express train coming up at the same moment, were all required to cause this truly dreadful event.

The object of the present paper is merely to consider one of these points, and to discuss the questions whether bridges, as now constructed, are sources of danger, and, if so, can the chances of accident therefrom be reduced by different forms of construction?

It is believed that there is no instance of a bridge, designed by an American civil engineer, having broken down from bad design, or insufficient material, as did the Dee bridge in England, designed by Robert Stephenson.

All the bridge accidents in this country, it is believed by the writer (and if mistaken, he hopes some member will correct the statement), have occurred either from the falling of temporary trestle work, or from weakness caused by decay, or from sudden shocks occurring when trains have run off the track. Our bridges, both of wood and iron, are safe so long as the trains remain upon the track. How many of them are absolutely safe under all circumstances? If not, how can we make them so? or at least diminish the chances of accident? This is the practical question.

It was a practice in English bridge construction introduced by Brunel, and now falling into disuse, to make the platform of a bridge in the shape of a trough, which was filled with gravel or broken stone ballast, and the ties laid in it, just as on earthworks.

The reasons given by Mr. Brunel for this were as follows :

1. To enable the alignment and level of the rails to be maintained by the same men and with the same tools as on other parts of the line.

2. To prevent concussion when a train came upon a bridge, as there was no change in the nature of the support given the rails.

* From a paper read before the American Society of Civil Engineers by Mr. Thos. C. Clarke.

3. To prevent vibration being transmitted to the iron-work of the bridge.

4. In case of trains getting off the rails, to prevent their ploughing through the flooring.

5. To protect timber flooring from fire.

6. To provide for changes of length caused by temperature.

7. To increase dead weight on short spans so that there might be no jar from the rapidly applied load of a locomotive.

It was Brunel's belief that the cost of the extra material required to support the ballast was more than compensated by the above advantages.

Most American engineers would say that the first object was of little consequence; that the second and third are equally well provided for by a wooden system of flooring; that to use ballast for the fifth would do more harm than good, because the timber and plank would rot unseen; the sixth can be accomplished more easily in other ways; and that the seventh had better be attained by making the iron-work heavier. The fourth, that of preventing trains ploughing through the floor, ought to be accomplished at any cost. But let us examine if there is not a better way.

The weight of the ballast itself averages about 500 lbs. per ft. run, and that of the additional parts of platform necessary to support it about 500 lbs. more. In other words, it weighs as much as the iron-work of an American truss bridge of 150 ft. span, or an English plate girder of 110 ft. span. This great addition of dead weight has prevented its adoption here, and caused its disuse in England.

The object which it was intended to accomplish was excellent, and it is to be feared that this has been too much neglected in the rough and ready style of construction adopted in our earlier bridges at least.

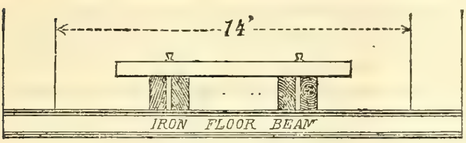


Fig. 1. Section.

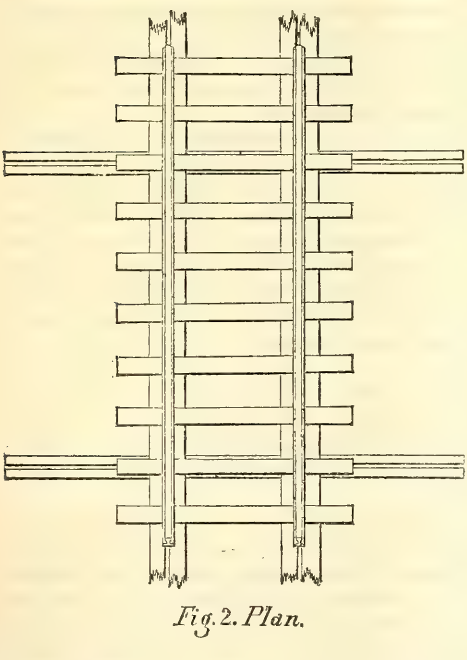


Fig. 2. Plan.

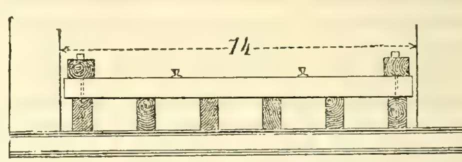


Fig. 3. Section.

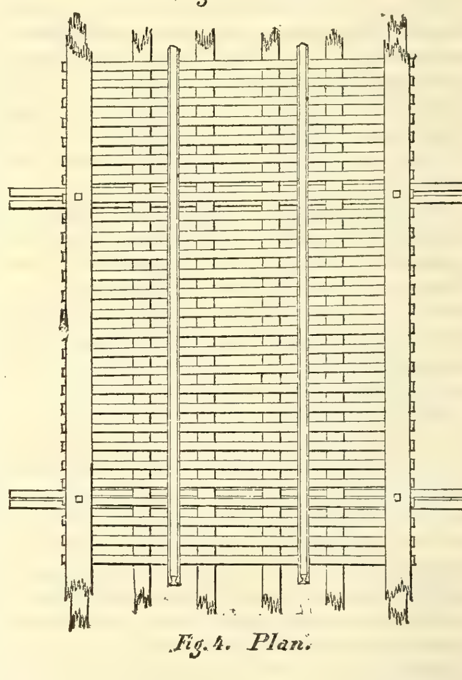


Fig. 4. Plan.

If the train jumps the track while crossing, it falls through a space equal to the height of rail............ $4\frac{1}{2}$ in.

"	"	track stringer...	12 "
"	"	cross tie.......	$5\frac{1}{2}$ "
			22

in. in all upon the floor beams, which, in most cases, would either be broken outright by the shock, or crowded apart by the wheels of the engine, so that it would drop through the bridge.

The arrangement of platform on most iron bridges is still more dangerous, as the floor beams, though of iron, are placed in pairs together, and from 10 to 15 ft. apart, so that there is nothing to prevent the engine from dropping between them if it once leaves the rails. This is shown in Figures 1 and 2.

There is a mode of construction shown in plan and section in Figs. 3 and 4, which is in use upon some of the Pennsylvania coal roads, which is much better provided to secure safety in case of trains leaving the rails.

The track stringers are numerous, and are strong enough to resist a severe shock. The ties are made of 4 x 12 in. plank on edge placed 6 or 8 in. apart, and blocked between every one, both at each end and under the rails. It will be observed :

1. That the distance that the wheels can fall cannot exceed the height of the rail or $4\frac{1}{2}$ in.

2. That the platform is broad enough to support the wheels even if the train is off the track.

3. That the ties are so close that the wheels cannot drop between them, and, being firmly blocked, cannot be crowded apart so as to leave a space through which a car or engine may fall.

In addition to this there should be heavy guard timbers, as shown, on each side, to prevent the engine striking the trusses of the bridge before its motion is arrested. There should also be a few planks spiked together lengthwise, so as to support the track in case of an axle or wheel breaking.

If such an arrangement does not insure perfect safety, it certainly diminishes the chances of danger far below those which are inseparable from the style of construction shown in the drawing, which it is believed is the style commonly used in this country.

As the one object of bridge building is to insure the safety of what is carried across the bridge, it would seem desirable that some of the superfluous talent which fills our engineering papers and magazines with elaborate calculations upon the strength of the parts of the main trusses of bridges, none of which were ever known to fail, should be diverted to drawing the attention of railway managers to a safer construction of the floor system than now prevails.

SHOEBURYNESS EXPERIMENTS.

From "Engineering."

An interesting series of experiments was carried out at Shoeburyness recently, upon which occasion the capabilities of a new target, designed by the War Office authorities, and the Prussian field-gun recently presented to this country, were tested. The target is of unusually large size, measuring 48 ft. long by 9 ft. high. Although built up in one, it really represents two systems of targets. In one the armor plating is 8 in. thick, with a backing of teak 18 in. thick and a $\frac{3}{4}$ in. iron skin with iron ribs in the rear. In the other the front plate is 8 in. thick, and is backed by $5\frac{1}{2}$ in. of teak, behind which is a 5-in. armor plate backed with 6 in. of teak and a $1\frac{1}{2}$-in. iron skin. The guns brought to bear upon this compound target with the 9-in. Woolwich muzzle-loading rifled 250-pounder, and the 11-in. Woolwich muzzle-loading rifled 500-pounder gun. The 9-in. gun was directed against the 8-in. armored portion, and the 11-in. gun was laid against the target carrying the 13-in. of divided armor, the ranges being in both cases 200 yards.

Both guns penetrated the targets, the 11-in. weapon doing exceptionally good work in sending its projectiles through the 2 armor plates and backing of the second target. Both plates were cleanly penetrated, the puncture disclosing the fact that the metal was of splendid quality.

The second part of the programme for the day consisted of comparative trials with the nominal 4-pounder breechloading Prussian rifled field-gun, fired with 9 lb. cylindrical projectiles, against the English muzzle-loading 9-pounder and 16-pounder field-guns. The general results of this practice were that the English 16-pounder fired 25 rounds in 13 min. 30 sec., making 14 hits upon the target; the English 9-pounder fired the same number of rounds in 8 min. 37 sec., scoring 13 hits; whilst the Prussian field-gun fired a like number of rounds in 10 min. 15 sec., making 13 hits. Competitive practice was then carried out with the 3 guns against targets representing troops, with good results.

A PROBLEM IN BRIDGE CONSTRUCTION.

By W. C. WILLITS.

It is proposed to determine the form of the upper chord of a trussed girder, loaded uniformly on either upper or lower chord, so that the lower chord being horizontal, the upper shall be strained uniformly along its entire length.

We will apply the principle of moments, adopting the following notation:

Let L = length of clear span.
" d = lever arm of strains for any bay of upper chord.
" d_1 = lever arm of strains for central bay.
" N = number of bays, counting on lower chord.
" l = length of each bay $\frac{L}{N}$.
" n = No. of any bay counting from the right.
" m = No. of the central bay.
" s = strain on any bay in upper chord.
" s_1 = " central bay.
" p = load on each bay.

Case 1*st*. A trussed girder as represented in Fig. 1. Uniform load on upper chord.

The moment of the forces which produce the moment of strain in any bay of the upper chord, are, the moment of the reaction of one of the supports, and the moment of the load between the support and the bay. Hence the moment of the strain on any bay of the upper chord about the vertex of the bay equals the difference of the moments of the other two forces about the same point.

We have, therefore,

$$s\,d = \frac{N\,p}{2} n\,.\,l - n\,p\frac{n\,l}{2} = \frac{(N-n)\,n\,p\,l}{2} \quad (1.)$$

which is a general expression for any form of upper chord; and this form moreover depends upon the values d and s, either of which may be assumed and the other found.

If d be made constant, it becomes a case of parallel chords, but if s be made constant the upper chord remains to be traced, which is the problem proposed.

From Eq. (1) we have the strain at the centre

$$s_1 = \frac{(N-m)\,m\,p\,l}{2\,d_1} \quad . \quad . \quad (2.)$$

from which s_1 can be determined by the known data in every girder.

Substituting this value of s_1 for s in Eq. (1), we find

$$d = \frac{(N-n)\,n\,d_1}{(N-m)\,m} \quad . \quad . \quad (3.)$$

this being the lever arm of any bay, it is the perpendicular distance from the vertex to the opposite chord.

Now, suppose L, N, d, and l, are known quantities.

The bay E F is parallel to the lower chord, and the points E and F are in the perpendiculars from the middle of the bay to K. F M = d, E K = l and M K = $\frac{1}{2}\,l$; hence F K can be calculated.

The position of the bay F G can be determined by calculating d for $n = (m-1)$, and describing an arc with K as a centre, and d as a radius, then drawing from F the line F G tangent to it, G will be in the perpendicular G N at the middle point of K Q.

For the next bay calculate d, when $n = (m-2)$, and proceed as before, each succeeding bay being determined in the same manner.

To determine the length of the bays and struts. In the right triangle F M K, F K and the angle a can be determined from the given data; then, in the right triangle F K P, P K and F K are known, P K being perpendicular to F G and equal to d, when $n = m-1$. From this triangle a can be computed; the sum of a and a_1 is equal to the angle which the bay F G makes with the vertical.

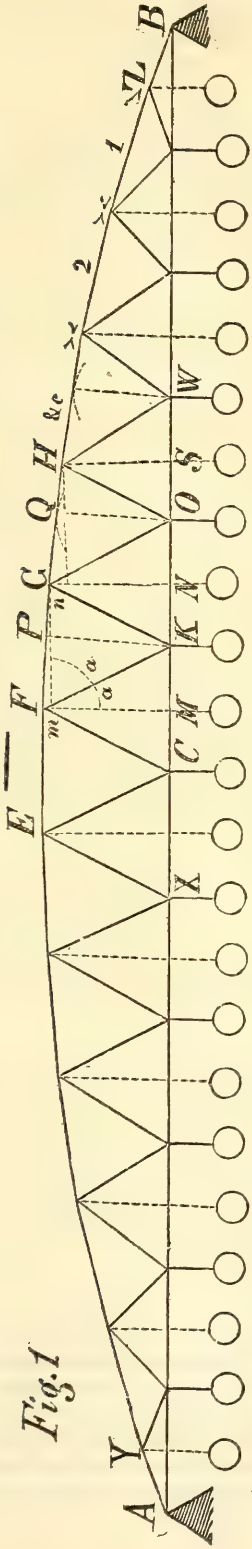


Fig. 1

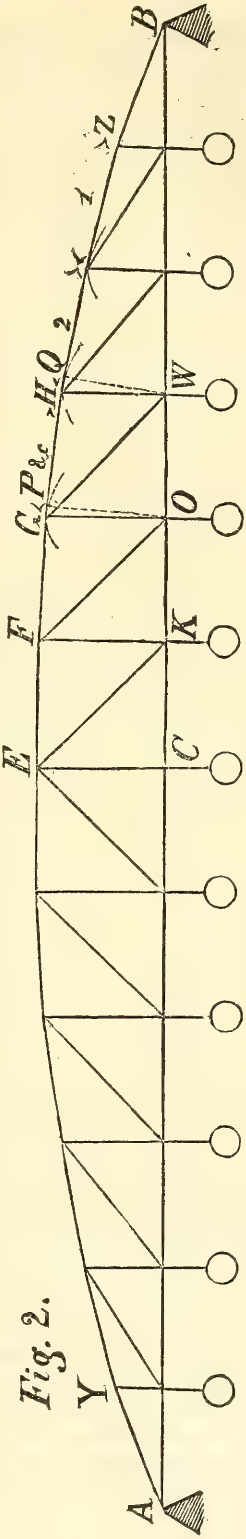


Fig. 2.

Draw m G parallel to A B; m G is equal to l. In the right triangle m F G, the angle F and the side m G being known, F G the bay and F m can be computed. If from M F we subtract m F there will remain N G, from which we can solve the right triangle G K N in which G K= G O. In like manner we can find H S, H O, H W, and the remaining struts and bays.

The numerical values of d are now readily determined.

If $L = 120$, $N = 12$, $l = 10$, and $d = 10$,

then by substituting in Eq. (3), we have

$$d = \frac{(N-n)\,n\,d_1}{(N-m)\,m} = \frac{(12-n)\,n\,10}{(12-6)\,6} = \frac{60\,n - 5\,n^2}{18}$$

If $n = 6$, $d = d_1 = 10$.
$n = 5$, $d = 9.7 +$.
$n = 4$, $d = 8.88$.
$n = 3$, $d = 7.50$.
$n = 2$, $d = 5.50$.
$n = 1$, $d = 3.05$.

It should have been remarked before that the upper chord in both figures extends from Y to Z, and that n is determined by counting as the numbers 1, 2, etc., indicate.

Case 2*d*. To solve the problem of the girder Fig. 1, when the load is on the lower chord.

Taking the moments, we have

$$s\,d = \frac{N-1}{2}\,n\,l\,p - (n-1)\,p\,\frac{n\,l}{2} = \frac{(N-n)\,n\,p\,l}{2} \quad (4.)$$

and from Eq. (4) we have for the strain at the centre,

$$s_1 = \frac{(N-m)\,m\,p\,l}{2\,d_1} \quad . \quad . \quad (5.)$$

Substituting this value in Eq. (4), we have

$$d = \frac{(N-n)\,n\,d_1}{(N-m)\,m} \quad . \quad . \quad . \quad (6.)$$

which is the same form as Eq. (3), and the discession from this point is as before.

Case 3*d*. To solve the problem for the trussed girder of form represented in Fig. 2; the load being on either upper or lower chord.

From the principle of moments we have

$$s\,d = \frac{N-1}{2}\,p\,n\,l - (n-1)\,p\,\frac{n-l}{2}$$
$$= \frac{(N-n)\,n\,p\,l}{2} \quad . \quad . \quad . \quad (7.)$$

the strain at the centre then will be

$$s_1 = \frac{(N-m)\,m\,p\,l}{2\,d_1}; \quad . \quad . \quad (8.)$$

by sustituting in (7) we get

$$d = \frac{(N-n)\,n\,d_1}{(N-m)\,m} \quad . \quad . \quad . \quad (9.)$$

Let L N and d_1 be given. The bay E F is parallel to the lower chord and is equal to l. F K is perpendicular to it and equals d_1. K O $= l$ by construction; from which data we can find F O and the angle F O K.

The line P O is perpendicular to the bay; F G by construction is equal to d, and is calculated from Eq. (9), by making $n = m - 1$. G is in F P and a perpendicular to A B at O. In the right triangle F O P, F O and O P are known, hence the angle O F P is readily computed.

In the triangle F O G we have the angles at F and O and the side F O; we can therefore determine the bay F G and tie G O.

From G O and O W (which equals l) we can find G W.

The method of finding the remaining ties, bays, and struts, is sufficiently explained in the foregoing. The parts on the left are of course duplicates of those on the right hand.

The numerical values of d for $L = 120$, $d_1 = 10$, $N = 12$, $l = 10$, are as follows:

Substituting in Eq. (9) where $m = 5$, we have

$$d = \frac{(12-n)\,n\,10}{(12-5)\,5} = \frac{24\,n - n^2}{7}$$

If $n = 5$, $d = 10$.
$n = 4$, $d = 9.14$.
$n = 3$, $d = 7.71$.
$n = 2$, $d = 5.71$.
$n = 1$, $d = 3.14$.

OMNIBUSES IN PARIS.—The revenue of the Parisian Omnibus Company is reviving. In the week ending June 17, the receipts were £12,836, against £17,958 in the corresponding week of 1870. The number of the Company's omnibuses at work was increased in the week ending June 17 to 500.

THE NORTH AMERICAN PACIFIC COAST.—Professor Agassiz, having had a coast survey steamer placed under his control, is examining the waters of the Pacific on the North American coast, and in connection with deep sea soundings he will collect specimens of natural history.

RESTORATION OF THE PLACE VENDOME COLUMN.

From "The Engineer."

Already the restoration of this column has been promised by the *de facto* Government of France. It is certain that the fallen monument could not be permitted to remain, a boast for the Communist, and a reproach to France, if so regardless of her own historical renown.

The *mode* of restoration must therefore soon come up for consideration; we therefore offer no apology for offering to our neighbors a suggestion as to this, in our capacity as exponents of British engineering.

At the date of its construction there was, perhaps, no alternative but that of clothing externally with bronze an interior core of masonry. Wholly of bronze the column could not be, iron was dear, and its manufacture in France little advanced; and France herself, relatively to even her now immediate future, was poor. Had it not been for this heavy and shaky stalk of soft masonry inside, the destroyers might have found their task, of *pulling* down at least, a more difficult one. In a word, the structure, taken as a whole, was a weak and rickety one, easily cut through in part, and then requiring little force to bring it down.

What we have now to say, then, is, let no masonry be employed in its reconstruction. Let the re-elevated column consist of a conico-cylindric shaft of boiler-plate work in 2 skins, an outer one adapted in diameter, taper, and contour, to the reception of the bronze spirals, and an inner one quite cylindric and prepared to receive a cast iron spiral staircase from bottom to top. Let those 2 great tubes be stiffened and kept concentric by a system of vertical radial ribs, also of boiler-plate work. The strength and *stiffness* of such a structure, as is well known from our iron lighthouse experience, is enormous. Socket the lower part well into the masonry filling of the square base, and also for some feet in depth down into the solid masonry of the foundation, and prepare the top for the reception of the capital, dome, and statue, as to the particulars of which we need not expend words.

The bronze spirals of *bassi relievi* should be *hung* on to the external iron tube by *boutons*—that is to say by bolt clamps, suitably designed to allow for the difference in expansion and contraction between the wrought iron of the less exposed tube, and the fully exposed bronze exterior through the whole range of the climate of Paris. In this there is no difficulty either, so we shall not go into details, but merely remark that upon such an iron surface many of the present spiral *plaques* of bronze—of which nearly the whole are stated to have been now recovered—may easily be restored to their places without their fractures being visible from below; those broken into fragments must, of course, be recast.

Now, what are the preferential advantages of this method over that of restoration, as at first, with a masonry core? They are—if we do not greatly err—a considerable saving in total cost, great rapidity of execution, no scaffolding being necessary at any stage of the progress ; a far more stiff and workmanlike job in the end; the capability of using once more many of the fractured bronzes, which otherwise must be recast; an enlarged interior cylindric area for the spiral staircase, thus rendered more commodious ; and, finally, the moving with the times—if that be worth anything—in thus employing metal, in place of masonry, in in union with another metal, the evils due to which we lately described.

One caution we may be permitted to give. A wrought iron interior structure, if consisting of thin vertical and diagonal members, a pair of lattice tubes in fact, will here not answer, though probably such would first be thought of by the inexperienced, as saving much material needful for the double tubes. Such a construction would probably be *strong* enough, but would be quite deficient in the necessary amount of *stiffness*. A remarkable instance of this became well known amongst ourselves some years ago. The water towers, originally designed for the Crystal Palace, consisted of vertical, horizontal, and diagonal members of cast and wrought iron, and were found to rock to and fro so dangerously that the late Mr. Brunel was employed to redesign them, and he produced *stiffness* by the introduction of thin cast iron rectangular panels

between the vertical members and the horizontal ones of each story, thus approximating to a tube in the outer shell. The column, reconstructed as we have suggested, might no doubt be shattered and blown down by gun-cotton or picrates, but it would probably overtask the engineering of some future Commune to *pull* it down.

France, amongst her many able engineers, possesses one pre-eminently fitted to design and carry out this work in the Place Vendome, viz., Monsieur Léonce Reynaud, chief engineer for the lighthouses of France, whose iron tower for the *phare*, upon the Douvres Rock, was a conspicuous object of the Parc at the Great Exhibition of Paris in 1867.

DUTCH INDUSTRY.

From "The English Mechanic and World of Science."

Dutch industry is scarcely less proverbial than Dutch cleanliness and Dutch art. Nor is the special repute implied by the title undeserved by a nation which has almost created a country for itself; barring out the sea, draining lakes, constructing canals fit for ocean traffic, and converting sand-hills into gardens. An opportunity of contemplating the peculiar genius and habits of this remarkable people is now afforded by the tardy publication—after 2 years' delay—of the Hon. T. J. Thurlow's special report upon the Amsterdam Exhibition. Mr. Thurlow, acting in concert with the able British Commissioner, Mr. P. L. Simmonds, who not only managed the English department, but had charge, as well, of all the scientific details, takes a thoroughly practical view of his subject, which is divided into 7 sections, not all of which fall within our scope. We propose to regard the Dutch, as represented by their industry, from a domestic and artificer point of view—in their homes and at their work; because, although no strict parallels of comparison can be drawn between them and the English of similar classes—owing to local circumstances—they may still teach a few lessons to the world around them. That, indeed, was the grand object of the Exhibition in 1869, and this important volume gives the entire results, faithfully and minutely. The Dutch, in their display, put the dwelling-house foremost, as the first requirement of civilized society; but they included, also, workingmen's institutions and the materials of building. Their plan consisted in reconciling the needs of the inhabitant with the interests of the proprietor, and the methods adopted deserve attention, it being premised that they apply to a very peculiar region. Holland contains no cities, like London, in which a square yard of freehold ground is scarcely less than an estate; but, on the other hand, most of her solid soil is artificial, possessing, therefore, an artificial value. Still, even this circumstance prevents the spreading of her towns over indefinite areas, so that the artisan, at his employment, can never be very distant from his home, whatever may be the case with the agricultural laborer. In the first place, nothing is more odious to your Dutchman than a "colony house" or "perpendicular street," as it has been called, a lodging of many floors, with a staircase which is a public thoroughfare, a common pump, a common well, a common cellarage, conducing to quarrels, and the destruction of real domesticity. But, hitherto, the poorer population of Dutch cities, notwithstanding all our romantic ideas on that topic, illusorily illustrated by the show village of Broek, near Amsterdam, which is forever clean and never inhabited, have been extremely ill-sheltered. In the capital they live, for the most part, in cavernous holes below the water level of the canals, always damp, often flooded, and condemned by medical science as most unhealthy. Since the Exhibition, strenuous exertions have been made to provide them with better homes, and much in this direction has been done. We begin with the single-story buildings. They have two rooms, a garret, and a cellar, besides an out-house; their cost is £92 each, and the rent about 2s. a week. The double-storied cottage has two rooms on the ground, with a bed recess in one, two rooms above, and a loft with a window in it; a ladder leading up, a stove, a chest, which is a fixture, a stone sink, and a

dresser, and water is laid on. These are far more popular than the four-house blocks on the Hague and Haarlem models, though their accommodations are infinitely superior. In these, the ceilings are composed of wood with a zinc lining. They let at from 2s. 6d. to 3s. a week, and the calculated net profit is 7 per cent. Even better are the cottages built by the Dutch Carpenters' Society. They are somewhat crowded with conveniences, so to speak; but the means of ventilation would be perfect were it not that the immediate instinct of a Dutch housewife is to stop up every aperture through which fresh air can enter or foul air escape. But the model of models is that of Dort, a village made, to all appearance, expressly for artists to study. They are double, facing east and west. Each has two floors, completely separate, the lower entered through a porch and door level with the garden, the upper approached by a flight of exterior steps. Thus, 4 families may inhabit the same building, as though the dwelling of each were completely detached. They may partition the cellars and lofts, or one may agree to take the loft, and the other the cellar, by arrangement. They need never meet; there need never be any collision between them ; all the appurtenances are distinct. We noticed in these pretty little abodes, an air of great comfort and solidity. They are built of hard yellow brick and roofed with blue tiles ; the flooring is of thick wood or strong beams, with good stucco ceilings underneath, and the cellars and kitchens are tiled. One iron bedstead, secured to the wall, is provided by the proprietor, and wooden bedsteads are altogether forbidden. Including all expenditure, even that of a bridge across the neighboring canal, a rental of half a crown a week for each leaves a profit of exactly 5 per cent. The Dutch resemble the English in one important respect. The wives of our agricultural laborers, according to the highest authority prefer having all the rooms on one floor. They say they are thus better enabled to look after the sick and the children. The Dort model, though of 2 stories, practically answers this end, the only difference being the necessity of a a gate or half-door in the porch of the upper flat. In all these structures, humble though they be, ample space is afforded for the storage of wood, coal, and those dried provisions in which your Hollander so characteristically delights. Curiously enough, however, it was left for an English firm—Messrs. Engert & Rolfe—to teach the Dutch how they might preserve their homes from damp. In Holland, where the foundations of all houses are literally laid in water, and where the common Archimedes screw pump has to be kept constantly at work while digging and building foundations, the invention of fibrous asphalt, to be laid between the courses of brickwork, preventing the passage of moisture upwards, is immensely appreciated. It seems stranger, too, that the Dutch rely upon us, principally, for their drainage-pipes, as well as for their apparatus of water supply. Now, having indicated the nature of the Dutch working man's dwelling, under the new order of things, and in the suburbs, let us see how he fills it with comfort. His principal idea of furniture, let it be said at once, is an abundance of pots and pans—for milk, for "roasting," for washing, for coffee, for filters, for pepper, mustard, sugar, and soap, for tea, eggs, and Schiedam. He loves, in his cottage pottery, to indulge in mournful mottoes. We once, by a Friesland fireside, after draining a deep mug of the purest Geneva, were warned at the bottom of it by the words, "Death must come." It is all plain work, resembling in no respect the tinted wares of France, Belgium, and Austria. So much for the "dresser" and the table. In the fire-place or, rather, stove, is chemically-prepared peat. In the kitchen is more hardware than could have been imagined within those limits—laundry irons, heaters, wash-tubs, and mangles, all seeming to be folded away when out of use. The bedding is of Kapok, a silky fibre, from the seed gourd of a tree known only in the Indies. From the seed is obtained oil, and with the refuse cattle are fed. Neither moth nor vermin will attack this material, and hence the Dutch are helped by nature to keep their households wholesome. But it is in his bedstead that the Dutchman exhibits the greatest pride. The niche in the wall is now almost universally condemned on sanitary grounds, throughout Europe. So the Dutchman puts his bed-room in a box, with all its accessories, and even contrives, sometimes, that a part of the ceiling shall descend at night in the form of a large flat

couch. He is fond of lamps, moreover; but he cares little or nothing for the paper hanger's trade. His clocks were once popular beyond the limits of the Netherlands; but now they are elsewhere out of date, superseded by English and United States manufactures. But nobody could have seen the peasantry flocking in and out of the Amsterdam Crystal Palace, without appreciating the importance of the white wooden tubs in the cottages, and being aware of the national devotion to starch. Of course, it is rice starch in Holland, and Mr. Simmonds, in a paper quoted by the Hon. Mr. Thurlow, shows how vast this manufacture is becoming. This leads to the department of clothing, and it may be noted that a Dutchman regards a tobacco-box as an article of wearing apparel. He is great in waterproofs, in all varieties of open air and sea-faring attire; he is supreme with brown duffles to keep the damp from the skin, as he is with oil from fir-cones to cure rheumatism, and pine-juice lozenges to strengthen the lungs, in his vaporous country. So, too, with wooden footgear, garden-shoes, swamp-shoes, sand-shoes, mud-boots, iron-workers' boots, and pigs' leather gaiters for well-sinkers. We do not dwell, passing from these classes to that of food, upon the peculiar nutriment affected by Dutchmen, since it lies beyond our purpose; but pass on to the collection of tools, very characteristic of the country—tools for gardeners, farm-laborers, dyke-workers, and boat and ship builders, and nets and tackle for fishermen. The Dutch have a strange objection to improvements in these respects, and their implements are, therefore, for the most part, of the most homely and ordinary kind. Their fishing-tackle is wonderfully varied in material and construction; but it is nearly all old-fashioned. Their dyke-workers' apparatus dates from beyond the Great Revolt. Their gold work and diamond cutting is done upon ancient methods. Their mill-stones, however, and who so great as authorities on the making of mills as they? exhibit continual improvement, and their coopery is magnificent. Oddly enough, however, they buy their best carpenters' benches from Austria, and carpentering is among the chief of industries in Holland, notwithstanding that there is not a wood worth speaking of in the entire region. It is the Rhine which brings them their enormous supplies of deal from the Black Forest. And what are the facilities afforded to the Dutch workman for making progress in his craft? There was at the Exhibition a large variety of models in various materials—wood, cork, card-board, and metal, including many of the celebrated buildings and most of the historical models in the Netherlands; with steam and water mills, locks, docks, and shipping; the drainage systems of towns and districts, foundations, staircases, gem-cutting engines, boring machines, and so on; with drawings from nature and from copies; and it is worth remarking here, that by the Dutch law there must be at least one technical school to every 10,000 of the total population. We agree with the report in believing that, in its practical results, the Amsterdam Exhibition was of exceeding value. To quote only one example, satisfaction was loudly expressed by the Dutch artisan at the opportunity afforded him of comparing, side by side, the tools of England with their Belgium imitations, the manufacturers of which frequently do not stop short of counterfeiting the trade-marks of the best known Sheffield firms. The result of the comparison was generally admitted to be in favor of British hardware, over the Continental manufacturers. "More than one Dutch carpenter," says Mr. Thurlow, "informed me triumphantly that his study of the two would enable him thenceforth to distinguish the real article, from its make and general cut, from the crafty imitation." They have much to learn from us, but we, also, have not a little to acquire, in course of time, from them, as they who study the official report will testify. Holland, as we have said, is in many senses—in a sense applying to no other country of the world—a creation of human industry. *Luctor et emergo* is its proud and legitimate motto. It has been recovered from the sea and enriched by the rivers. The patient people still continue to contend with the elements along their maritime and inland water boundaries, in the foundations of their cities; in the manufacture, so to speak, of cultivable soil for their fields and gardens. They are slow, but they never cease progressing. They are not particularly inventive, except in matters of sea walls and windmills; but they are apt at mechanical adaptation.

Steam power is less available for them than for other nations, owing to the paucity of fuel, because where peat is dug lakes are formed, which is a check upon the process, and coal is comparatively dear, because it has to be bought in Belgium or England. In point of fact, there was hardly any Dutch steam machinery in the Great International Exhibition at Amsterdam.

But in their mighty drainage works they have found this species of power to be essential. In one place, 3 English-built engines superseded 140 windmills, and there was no question about the economy of the change. The Netherlands farmers, who reap the benefit of these reclamations, are still, or were until 1869, very imperfectly acquainted with our best instruments of cultivation—clod-crushers, drills, manure distributors, and dibbles; yet they understand the land they have to till, and upon the whole, their management of it and industrial life in it, are studies in civilization worth the notice of all practical minds.

THE TRANSPORT OF EXPLOSIVES.

From "Engineering."

A question of considerable importance to all those who are interested in tunnelling or mining operations is now being warmly discussed in certain quarters. This question has reference to the propriety of the Government relaxing some of the more stringent clauses of an Act of Parliament passed in the year 1869, and which prohibits the importation, and restricts and regulates the carriage, of nitro-glycerine and all substances containing it. The Act was framed and hastily carried through Parliament at a time when carelessness in the transport and handling of nitro-glycerine had caused several fearful accidents, both at home and abroad. Unquestionably this stringent piece of legislation was much needed at the time, and it afforded protection to life and property which had previously been much jeopardized. Nitro-glycerine is confessedly a highly dangerous substance; but it was such an invaluable material in mining operations that great risks were run in order to obtain it, as by its use much labor was saved, and much gain resulted. Nor was the running of these risks altogether unreasonable or inexcusable. By the use of nitro-glycerine, mines could be worked which were well-nigh being given up, from the excessive cost of blasting with gunpowder. But still the State was perfectly justified in stepping in to protect the subject against himself as well as against his neighbor. Since the passing of the Nitro-glycerine Act, however, science has advanced, and we now have explosive compounds as powerful as nitro-glycerine, and yet absolutely safer than gunpowder. Such are dynamite and lithofracteur, the former a well known explosive, eminently satisfactory, alike in force and safety, and the latter, though less known, a powerful and safe material. On pages 343, 356 of the present volume will be found details of experiments with this material which proved its harmlessness under all conditions except those of actual work, although it contains a large percentage of nitro-glycerine.

But the satisfaction of a score or so of scientific men upon this point was not the aim and end of the experiments, nor of those connected with them. Having publicly established the safe nature of the material, it was desired to place the facts before the Secretary of State for the Home Department with a view of obtaining permission for its introduction into this country free of the more prohibitory restrictions of the Nitro-glycerine Act. With this object a deputation consisting of nearly 20 members of Parliament, and a number of other gentlemen representing mining, scientific, and commercial interests, waited on Mr. Bruce on this day week, and were received by him in the House of Commons. The deputation was introduced by Mr. S. Holland, M. P. for Merionethshire, who stated the object of the application, which was in effect to obtain permission to import lithofracteur into England, and also to manufacture it here under proper restrictions. Mr. R. S. France—the gentleman at whose quarries the recent lithofracteur experiments took place—explained to Mr. Bruce the nature and results of those experiments. He

also urged the desirability of having an explosive material possessing such power and safety as lithofracteur freely introduced into England for mining and quarrying purposes. A large shipowner, Mr. Houlder, who was also present at the experiments, stated that he was perfectly satisfied with the safety of the compound, and expressed a hope that in the interests of commerce the heavy prohibition at present existing against its transport, would be removed. An observation from Mr. Bruce upon the peculiarity of the name of the material, led Mr. France to remark that Messrs. Krebs, the manufacturers at Cologne, intended to alter the name to that of "Krebs' explosive." With regard to the application, Mr. Bruce observed that his personal opinion in the matter went for nothing; he could only act upon that of his scientific advisers, inasmuch as the responsibility would rest upon himself. The statements made, taken by themselves, appeared very conclusive, and he was most averse to interfering with the use of anything which was a safe and powerful explosive. His object would be to encourage its manufacture, and he would have the matter looked into at once.

Of course there is nothing conclusive in all this, nor could it be expected that there should be. But the position matters have assumed with regard to the introduction of safe explosives is hopeful for the promoters of the movement, and in the interests of commerce and progress we are glad to see it. There can in fact now be no valid reason why the permission sought should not be granted. The Nitro-glycerine Act specifically states that if it is shown to the Secretary of State that any substance having nitro-glycerine in any form as one of its component parts can be safely imported, he may authorize its introduction into the United Kingdom. That dynamite and its kindred materials can be safely imported we have no doubt whatever. In support of this opinion we have but to refer to their extensive use on the Continent and to the Shrewsbury experiments. We therefore see no reason why Mr. Bruce should not grant the permission requested, and thus relieve those interested in mining and quarrying from the hardship they now suffer in not being able to avail themselves of materials eminently adapted for their purposes.

PRESERVATION OF SHEET-IRON VESSELS.

By C. WIDEMANN.

From the "Journal of Applied Chemistry."

The sheet iron used in naval constructions is very heterogeneous, from which electrical currents are generated, soon causing the decomposition of the water, or of the salts held in solution in it; thus quickly destroying the iron sheets by oxidation; the part that first become damaged is where heavy deposits of shells and weeds accumulate, which impede the speed of the vessels.

MM. Demance and Bertin have endeavored to prevent this destructive oxidation, the original cause of these deposits. By their peculiar arrangement the whole vessel is transformed into a kind of large Volta cup battery; large zinc holders in the shape of tanks or cylinders, are placed against the internal sides of the vessel; these holders are kept in perfect electrical communication with the frame and outside portion of the vessel by means of rivets, etc., or any other suitable connections, and they are daily filled with salt water; blades of zinc crossing each other, and passing over the outside of the vessel, are also connected with the holders; by the oxidation of the zinc these charge it with negative electricity, transmitting it by conductibility to the iron of the vessel, which thus becomes similar to an immense electrode charged with this negative fluid.

The authors at first believed that the iron thus coated by an envelope of negative fluid would by that reason acquire a certain electrical polarization, and thus be preserved from the action of the electronegative bodies, either contained in the atmosphere or the sea water; the negative fluid was to disappear in a regular way in the water, and the positive fluid of the liquid slowly disappear in the damp atmosphere, and this action taking place independently of the currents in the in-

side of the vessel, between the liquid contained in the tanks, and the iron works of the vessel, connected as it was by rivets, etc.; but the vessels thus armed have not proved a success, the interior was well preserved, but the outside very soon showed signs of oxidation.

MM. Demance and Bertin then continued the action of the holders by means of a small zinc blade fixed on the exterior of the vessel, in electrical communication with the tanks, and dipping in the sea water at its lower end. Experiments made under these circumstances have proved a complete success; and vessels thus protected have, after long voyages, shown no signs of oxidation, while other vessels, within the same period of time, and under the same circumstances, have been thoroughly oxidized.

These experiments suggested to M. Schussler, of the Metropolitan Gas Works, and the writer, the idea of applying this principle to gas holders used in gas works; these holders are usually made of sheet iron, and, as the Metropolitan Gas Company used the salt Hudson River water in their gas holder tanks, the oxidation was very rapid, destroying the iron, and preventing the coat of paint from adhering to the sheets.

In our first experiments, we introduced small pieces of sheet iron into different liquids and water at different degrees of strength as to the quantity of salts dissolved in them; the sheet iron very soon became oxidized, and having applied the principle of MM. Demance and Bertin, by connecting the piece of sheet iron with a small blade of zinc, the oxidation was prevented, and this piece, although having been in brine for over 7 months, has not yet shown the least sign of oxidation; I believe that the same principle could be applied to all iron work exposed to sea water, or even in moist soil; gas posts in streets might also be thus prevented from oxidation.

THE SELECTION AND USE OF STONE FOR ENGINEERING AND ARCHITECTURAL PURPOSES.

By MR. ARTHUR C. PAIN.

From "The Building News."

The use of stone dates back to the earliest of times, at first for sling stones, arrow and spear heads, and in the catapult.. It is not as a weapon of offence, however, that I propose to treat on it to-night, but principally as a weapon of defence against the two elements, fire and water, in the construction of breakwaters, docks, and public and private buildings. For these purposes it was the first material used, and although various artificial materials, such as brick, terra cotta, cement, concrete, etc., have been invented, and used with varying success, still it holds its own against them all; neither can we be surprised when we consider its great natural advantages. It is easy to hand, no making, baking, burning, or mixing, to be done, and widely spread in large and small quantities of all qualities all over the world. In the construction of breakwaters, piers, and arches of bridges, river-walls, lintels over wide spaces or for heavy cornices—indeed, wherever strength and weight are required, or heavy blows or weights have to be resisted, it is unequalled. It can be had of any size or shape and of any quality, from the great blocks of rough hard granite, tons in weight, used in sea defences, down to the fine even grain of the Oolites, some of which are capable of being carved almost as elaborately as wood. Some have argued that stone is not so durable as brick or terra-cotta, or indeed, cement. I have no desire to dispute the powers of lasting of these materials when good. But surely our own old cathedrals and castles, to say nothing of the Pyramids of Egypt, supposed to have been built 1,600 years B. C., are sufficient proof to show that where reasonable care is exercised in its selection, it is good for "all time." In all materials there are various qualities, and it is no argument to take the best example of say cement work, and compare it against the worst of stone, and then contend that cement dressings are as good as stone. Where clay is plentiful, brickwork is generally cheaper than stonework; but if much labor is required, as

in axed arches or moulded and rubbed brickwork, stone can be used generally quite as cheaply.

If we take terra-cotta, there is no economy in its use, unless you make a great number of articles of the same pattern; even then, the burning twists and warps it so, that if of any size it is very difficult to get the work true; whereas stone can generally be had soft or hard, of various colors, and of any size. Some short time ago a gentleman writing on stone endeavored to prove that stone used out of the district where it was quarried did not stand so well as in the neighborhood, because the foreign climate did not agree with it. Nothing can be more absurd or illogical. Why should a piece of granite from Guernsey decay faster if used at Aberdeen, instead of at St. Peter's Port? How such an idea could ever have been seriously promulgated, all reasoning persons must be at a loss to understand.

Stone having so many advantages, and being so much used, it is surprising that it has not been made a branch of study in the education of the engineer and architect. The remarks of the late Sir H. de la Beche on this point, although written upwards of 30 years ago, are still applicable to the present time. He says: "There was much excuse for the accidental durability of the stones employed in public or large private edifices in the former days when the mineralogical structure of building materials was so little understood, and the architect of those times could not always have churches or castles before them, from which they might judge of the relative durability of any stone they were about to employ, the quarries opened by them being also the first worked, to any considerable extent."

The architects and engineers of the present day cannot, however, avail themselves of these excuses, for the necessary chemical and mineralogical knowledge is readily acquired, and the number of public and private edifices of various dates scattered over the country is so great that the relative durability of the materials employed in their construction can easily be seen. It is, nevertheless, well-known that with some few exceptions the mineralogical character of the stone employed in public works and buildings has hitherto received little attention from either architects or civil engineers in this country, more especially from the former, whose value of a material seems commonly to have been guided by the opinion of the mason. Now the mason seems almost always guided in his opinion by the freedom with which a stone works—no doubt an important element in the cost of a building, but certainly one which should not be permitted to weigh heavier in the scale than durability; and hence many a fine public or large private building is doomed to decay, even in some cases within a few years. It is a common practice for young men who are intended to be brought up to be civil engineers to serve for some time in the works of a mechanical engineer, with a view to learn the uses and properties of metals. So with those intended for the architectural profession; they are taught first to be carpenters or joiners, to learn the uses and properties of timber. Why should not a young man who is desirous of entering either profession, also learn some knowledge of quarrying and masonry by practical experience in the quarry and at the banker? Surely stone is as important a material as either iron or wood in the construction of engineering and architectural works? Perhaps no more practical engineer ever lived than Thomas Telford, and he began life as a stonemason in Scotland. The importance of a proper knowledge of the selection and use of stone to engineers and architects can hardly be overrated. Indeed, some idea of its commercial importance may be gained by a knowledge of the fact that the value of the stone raised every year in the United Kingdom is said to be nearly if not quite £5,000,000. I shall, therefore, without further comment, commence the first part of my paper—namely,

THE SELECTION OF STONE.

Geologists tell us that the great divisions of rocks are classed according to the fossils that are found in them, and by the term fossil must be understood to mean any body, whether animal or vegetable, buried in the earth by natural causes. Rocks known by this test are termed generally aqueous, sedimentary, or fossiliferous, supposed to have been formed by the action of water on the earth's surface; these are stratified or divided into layers. From these rocks are raised most of the principal building stones, certainly those easiest to work. Other rocks are classed

as volcanic ; these are, for the most part, unstratified and devoid of fossils ; they are supposed to have been forced up through the various overlying strata, and flown into and over the same by the action of fire. They are known generally by their columnar and globular structure. These produce not only building stone, but stones which are used for ornamental purposes more than any other kind of rock. Further, we have Plutonic rocks, highly crystalline, and destitute of organic remains. They are supposed to be all of igneous origin, but to have been formed under great pressure ; they have been melted, but cooled and crystallized very slowly. They differ from the volcanic by their more crystalline texture, and by the absence of pores and cellular cavities. From these rocks we have some of the finest, hardest, and most durable of building stone. Lastly, we come to the metamorphic or stratified crystalline rocks. The origin of these is more doubtful than any of the other three classes ; they contain no pebbles, sand, or angular pieces of stone or traces of organic bodies, often as crystalline as granite, yet divided into beds. They are supposed to have been deposited from water, but afterwards altered by subterranean heat so as to assume a new texture. Building stone is not raised so largely from these rocks as from the others. Many of the white marbles are, however, metamorphic. Nearly all the various systems embraced under the name of aqueous rocks produce sandstones and limestones of various kinds. It is important to remember this, as very frequently a stone is called oolitic or carboniferous from the system to which it belongs, when, perhaps, to the eye, it might not exhibit the more particular characteristics of the formation. In a paper read by our President in March, 1862, he treated all the various building stones in each geological formation. I propose, therefore, to make my remarks more on the practice than the theory of the selection and use of stone.

In selecting a quarry from which to get the stone best suited to the purpose for which you want it, great care is required. Having first satisfied yourself that stone of the size required can be obtained, and at a reasonable price, the next and most important step of all is to find out if it is a durable stone. Too much weight must not be placed on the assurance of the quarrymen that the particular bed which is the cheapest for them to get is the "best," and, by that word, I mean the most durable ; not, as it is often understood amongst quarrymen and masons, the prettiest-looking stone and the easiest to work. Again it does not follow that because certain old buildings, small or great, in the neighborhood have lasted well, therefore all the quarries in the neighborhood produce the same stone. In some cases the best beds have been worked out because the strata only crop out at one place, and for the same reason a quarry on one side of a hill very often produces much better stone than on the other. Specimens of stone dressed up square, sent out by the quarrymen or agent, known as hand specimens, are very dangerous things to form an opinion on, because what looks very well in small pieces is really often of an inferior quality, and a stone that would appear coarse and rough in a specimen would not do so when in the mass. Stones that rub up to a smooth face are often not so durable as those of a rougher texture. To give an example, "best bed" Portland is much superior in color and texture to "brown bed" Portland, but far inferior to it in durability. Examine all the different beds in a quarry, noting the particular grain, texture, and color, of each bed; compare them with the buildings around, and if there be any old quarries near with the face exposed, see which of the beds stand out the most and show the old tool marks, and consequently have yielded to the action of the weather least. It frequently happens that the best stone in quarries is neglected, or only in part worked, from the cost of baring and removing those beds with which it may be associated and, in consequence, the inferior material is in such cases quarried, especially when a large supply is required in a short space of time, and at an insufficient price, which is often the case with respect to works undertaken by contract. As an economical supply of stone in particular localities would sometimes appear to depend on accidental circumstances, such as the cost of quarrying, the degree of facility in transport, and the prejudice that generally exists in favor of a material that has been long in use; and as the means of transport have of late years been greatly increased, it becomes essential to ascertain whether

better materials than those which have been employed in any given place may not be obtained from other, although distant localities, upon equally advantageous terms.

The relative facility with which good materials may be obtained in a district is, to a certain extent, marked by the appearance of the towns and villages in it, the comparative cost of obtaining them being in general better shown by the character of the ordinary houses than by that of the public buildings and large mansions, the stone for which may sometimes have been brought from comparatively considerable distances. From the frequent practice, however, of selecting those stones which yield readily to the tool, and are hence commonly termed freestones, whatever may be their mineralogical character, the most durable, and therefore eventually the cheapest, are far from being always employed. And it sometimes happens that we find the common cottages built of durable materials, while larger mansions and public buildings are not, the materials for the latter having been selected because they were soon readily worked up for ornamental parts, while those for the former may have been thrown aside in the same quarries because they yielded less freely to the tool.

In passing through the chief towns of Great Britain it will be easily seen, if more attention were paid to the mineralogical character of the stone employed in the construction of the buildings, that frequent decay or decomposition, even in those erected within a few years, which we so often observe, would be avoided at comparatively small cost, and we should find fewer of our public edifices losing all traces of the finer work of the original structure. In estimating the relative durability of any given stone which may appear to resist decomposition from atmospheric influence in the country, no doubt due allowance should be made for the power of lichens to protect the external surface. These are not usually found in large towns, particularly those in which there is much coal smoke. We should not expect a sandstone, formed of quartz grains, loosely cemented by calcareous or argillaceous matter, to last so long when exposed to the weather, as one in which quartz grains were firmly bound together by a compact argillaceous or silicious substance. According to the texture and variable composition of the different calcareous and calciferous rocks, a judgment may be formed of their relative durability, and granites in which decomposition has already commenced in the felspar cannot be expected to remain firm under atmospheric influences.

The unequal state of preservation of many buildings, often produced by the varied quality of the stone employed in them, although it may have been taken from the same quarry, shows the propriety of a minute examination of the quarries themselves, in order to acquire a proper knowledge of the particular beds from whence the different varieties have been obtained. An inspection of quarries is also desirable for the purpose of ascertaining their power of supply, the probable extent of any given bed, and many other matters of practical importance.

An excellent and ready test when in the quarry, is to chip a number of small pieces off each bed or block, and carefully examine them under a small but powerful magnifying-glass. If the fracture is clean and sharp, and the grains are well cemented together, then it may be considered a durable stone; but, on the other hand, if the fracture has a powdery appearance, and the grains are ill-cemented, the stone is very likely to decay. Another test of a good stone, not alone applicable to limestones, is to soak a number of small pieces in diluted sulphuric acid for some days; its resistance to disintegration under this test shows its suitability or otherwise for building purposes in a large town, as well as where exposed to the salt rains and winds in situations near the sea.

In the construction of lines of railway and other large public works stone is frequently used which is obtained from the cuttings or excavations. Now the contractor, generally to save cost, blasts the stone, which is a most fatal mistake if durability is required. For although it may not be at first apparent, the blasting shakes the stone, and, before many winters are over, the stone begins to crumble to pieces. Of course, in the case of granite and other very hard stones, this remark does not apply, for having little or no stratification it cannot be quarried without blasting. If it is desired to put nothing but good stone into a structure, the material should be quarried and

weathered for some time before being used, as this serves not only as a check against the use of inferior stone, but prevents the unsightly greening after erection, which, for a time, so often disfigures a building, even if built of the most durable stone. At the Bath quarries some of the stone raised in the winter time is stacked in the workings and dried by coke fires in brasiers. Some stones, if wrought and put into a building green, with the quarry water in it, will go to pieces under the first frost, whilst the same stone, if seasoned under cover, will often stand well. In choosing a particular bed of stone in a quarry, it must be remembered that the lowest beds are not always the best. For instance, in the Portland series the hardest and most durable bed is on the top.

It is often desirable for stone to be tested by having a chemical analysis made, also by a hydraulic pressure for the crushing strength, as well as in a testing machine to obtain its tensile strength. In all these cases the specimens should be taken from various parts of the quarry,and from each bed, and certainly not less than six specimens should be selected from each to arrive at reliable results. We now come to the second division of my paper, on

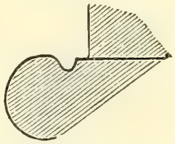
THE USE OF STONE.

Having found the quarry which produces stone of the quality you require, the next step is to specify the particular bed or beds which you desire to use. There is a great deal of looseness on this point in the practice of engineers and architects. Too often a stone of a particular district is specified without regard to the fact that, in the district named, stone of many different qualities is raised, some of which cost much more to work than others. This of course leads but to one result: the most profitable stone for the quarryman and mason is used, instead of the most durable. Another great evil is the outcry for large blocks, and the insisting that columns, figures, etc., should be cut out of one piece of stone. Many a good bed and quarry has been closed or rejected because it did not produce large blocks. Witness the case of the Mansfield Woodhouse quarries, where the stone was only used to a very small extent in the Houses of Parliament, because at that time blocks could not be got out large enough; but where it was used it has stood exceptionally well in contrast to the stone from Anston, which appears to have been selected principally because large blocks could be obtained.

In specifying the qualities and sorts of stone to be used in a structure, it should be remembered that in this climate decomposition sets in generally on the parts facing the S. S. W. and W., arising from the fact that the most prevalent storms of wind and rain are from those quarters. Lichens, which are a great protection to stone, unfortunately won't grow on structures in large towns, but they form an excellent shield to the stone in the country.

A great deal has yet to be learnt as to the proper use of the various and beautiful colors of different kinds of stone, and it is of more importance to have variation of color in a large town, because the fronts exposed to the wind and rain will always exhibit, more or less, the natural color of the stone, not being hid by lichens, as in the country. Some stone stands very well as ashlar or for plain mouldings, but if used for cornices, plinths, or in any part where damp or where the wet stands, so surely will it decay. It, therefore, is very necessary to specify one kind for the ordinary face work and a stone of superior durability for the portions exposed to wet and frost. However durable the stone may be, a good drip or weathering should be given to cornices or heavy projecting strings, as it enables the rain not only to run off, but at the same time to carry with it any dirt or dust that may have lodged on it, which, if left, grows moss and weeds, both very injurious to the durability of the stone. Fig. 1 is a very bad section of

FIG. 1.



base moulding, frequently used in early English work, for all the wet and dirt washed off the work above lodges in the sinking, and the frost gets in and attacks the stone at its weakest point—viz., the joints.

The use of metal cramps, iron particularly, is very objectionable; they nearly

always burst the stone after a time; slate dowels are the best. The stone parapet walls on the Thames Embankments are all built with slate dowels. Some of the masonry in the lower portions of Sir Christopher Wren's towers at Westminster Abbey are specimens of the evils of metal cramps. Bedding stone properly is a most important thing. It is a vicious plan to make the bed of columns or other masonry hollow, instead of true and square with the face; it invariably causes the stone to spall at the outside of the joint, as in the case of the Holborn Viaduct, besides causing the weight very often to be thrown on parts not intended to carry it, and a host of other evils, not to mention the unsightliness of walls and columns cracked in all directions. In masonry the joints should never, as a rule, be mitred, as is shown in

Fig. 2.

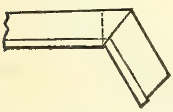


Fig. 3.

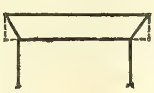
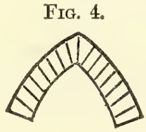


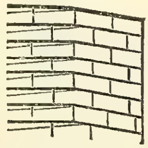
Fig. 2; or in lintels, as in Fig. 3, but as shown by the dotted lines. There is one exception to this rule, namely, in the case of a pointed arch which should be jointed

Fig. 4.



in the centre (Fig. 4); not with a keystone, as in a segmental arch. Where the stratum is thin, and the structure is exposed to heavy, driving rains, the outer courses of stone are often bedded at a slight angle outwards and downwards, as in Fig. 5, and the mortar is kept back an

Fig. 5.



inch or so from the face. This is done to keep the interior dry by preventing the rain from driving through the joints.

In designing rubble walls for buildings they should not be shown too thick, for if they are the masons are apt to build it with two faces, and to fill up the centre with loose rubble, often with little or no mortar. If exposed to vibration of any kind, they are very liable to burst. I have seen a great number of instances of this —one in particular, a church tower in the Lake district, which was cracked from top to bottom and all round—in fact, bursting under the vibration caused by ringing the bells, and the superincumbent weight of the spire.

In walling, masons always like to put the best face of a stone outwards, and the result is, you get large spaces which are filled up with mortar and spalls; few workmen can resist the temptation to put a long stone parallel with the face of the work, instead of endways. The want of bond stones is the great defect of walling generally. A good plan where the stone runs small is to build three or more courses of brickwork right through at certain levels to act as a tie. With stone from most geological formations, it is of great importance that it be placed bedwise, or as it lay in the quarry. This, if not properly attended to, leads rapidly to general decay. There are various methods of finding the beds of stone—for instance, rains always run from top to bottom, or with a downward direction. Shells or fragments of shells lie flat as they would on the sea-shore. In most sandstones the streaks or layers exhibit the bed very plainly.

In conglomerates, the pebbles, like the shells, are generally lying on the flat side. Added to all these, it is generally usual for the quarryman, before sending the block away, to mark on it which is the bed. The bed is therefore not so hard to find as some try to show, and a little careful examination of the peculiarities of the particular stone you are using will make you to detect at once if the stone is on its bed or not. After a structure is erected, or, as in the Scotch method, during construction, it is usual, if the work is of any moment, to clean it down; too much attention cannot be paid to seeing that all the mortar and slush is thoroughly washed off, for if it be not, the frost and rain will bring it off, and it gathers on the projections and under the mouldings, causing them to decay. It is a common practice, when a stone gets dirty or discolored, or is decaying, to cut or drag off the surface of the stone. This should never be done, for if the stone is dirty it can be rubbed

and washed to get it clean. Stone throws out, as it were, a hard skin for its protection when first exposed, and if that skin be taken away the protection is gone, and it is very liable to decay. If the stone is really decaying, any number of new faces won't stop it. In the construction of works where much stone is used, it is very important to have clerks of works and inspectors who have served as masons. In the greater number of cases it will be found that in early life most of the clerks of works, inspectors, and foremen have been carpenters or joiners. Too often you find masons knowing nothing beyond their trade, while carpenters and joiners are a better informed and superior class of workmen. A great deal of the inferior stone that is used, and the bad bedding that is permitted, is due, I think, to the fact that the workmen know that their masters are not masons. I am not finding fault with the men who by their industry have raised themselves from journeymen to positions of trust. Far from it, it is most creditable to them ; but on the other hand, it is equally discreditable to the masons that they allow the journeymen from another trade to take posts of trust which they might fill with greater advantage, where stone is much used, if they were steady and educated themselves for it.

Although I must now come to a close, do not think the subject is exhausted. I could say a great deal more on this important material; but as I hope there will be a valuable discussion afterwards from the members and gentlemen present, some of whom are connected with quarries, I shall defer any further observations to a future time. In some parts of my paper I have made extracts from Sir Charles Lyell's and Sir H. De la Beche's valuable works, from blue-books, and other publications which I have consulted. To those familiar with works treating on stone (I am sorry to say, very limited in number), these extracts will be at once apparent. In conclusion, if engineers and architects really desire durability, they must be prepared to pay a reasonable price, both for the raw material and the workmanship on it; and they will, I think, find that they will be heartily seconded in their endeavors, both by the quarryman and mason, in the selection of the best stone ; and in the long run it will prove not only one of the best of building materials, but the cheapest.

SOLAR HEAT—ITS INFLUENCE ON THE EARTH'S ROTARY VELOCITY.

By CAPTAIN JOHN ERICSSON.

(*Continued from page* 14.)

The unpublished tables containing the rivers flowing towards the poles, referred to in the preceding article, furnish elements relating to the latitude of and weight transferred by 102 rivers, 24 of which discharge directly into the Arctic Ocean, draining 5,351,000 sq. miles of basin. The remaining 78 rivers drain 7,833,000 sq. miles ; hence an area of 13,184,000 sq. miles comprises the entire river system of both hemispheres conveying water towards the *poles*. It is a noteworthy circumstance that nearly an equal extent of area is drained by the rivers flowing towards the *equator*, viz., 13,246,000 sq. miles. (See the Tables published in a preceding article.)

The mean latitude of outlet of the 24 rivers which discharge directly into the Arctic Ocean, is 69 deg. 15 min.; that of the centre of their basins is 60 deg. 3 min. Now the velocity round the earth's axis of rotation in parallel 69 deg. 15 min. being 538.16 ft. per second, while that of parallel 60 deg. 3 min. is 758.22 ft. per second, it will be seen that the mean rotary velocity of the water during its course from the centre of the basins to the points where it enters the polar sea, is diminished 220.06 ft. per second. The unpublished tables before referred to, show that this diminution of rotary velocity of the waters conveyed by the Arctic rivers, imparts a mechanical energy of 91,111,578,300 foot-pounds per second to the earth (a computation, it should be observed, based on the assumption that the precipitation on the basins of the 24 Arctic rivers varies, ac-

cording to latitude, from 20 in. to 11 in. in 12 months). The water of the remaining 78 rivers flowing towards the poles—including river La Plata, but excluding the Nile—imparts, as shown by the tables, a rotary energy of only 20,399,766,300 foot-pounds per second. It will be found, on examination, that the outlets of the rivers imparting this small *compensating* energy are removed so far from the tropics, and hence from the direct influence of a vertical sun, that the water which they discharge cannot be converted into vapor until it has reached, in its course towards the equator, a position much further from the poles than the centre of the respective river basins. La Plata might possibly be deemed an exception, but several of the other 77 rivers under consideration transfer their waters, as stated, to positions much nearer the equator than the centre of their basins, before complete evaporation takes place. We shall, therefore, overestimate the compensating energy exerted by these rivers, if we assume that their water in its course through the ocean towards the equator, becomes evaporated by the time it crosses the parallels corresponding with the centre of the basins from whence the motion proceeds. Consequently the compensating force of 20,399,766,300 foot-pounds per second, will be wholly neutralized by the retarding energy called forth during the stated return movement of the water. Indeed a critical examination of the subject could not fail to show that some *retardation* actually takes place. The amount, however, is too small to affect materially the general question of retardation of the earth's rotary velocity, and therefore may be neglected. But the compensating energy of the water of the 24 rivers discharging into the Arctic Ocean, is so far inferior to the *retarding* energy called forth during the retrograde motion towards the tropical seas, that the earth's axial rotation suffers an amount of retardation which, as already shown, considerably exceeds that of all the rivers flowing in the direction of the equator.

The following additional explanation will more fully elucidate the subject. It was shown in a preceding article that the water discharged into the cold polar sea, in place of being there converted into vapor, at once commences a retrograde motion towards the tropical seas; and that owing to this retrograde motion and the consequent retreat of the circulating water from the axis of rotation, the whole of the compensating energy imparted to the earth will be neutralized by the time a parallel is reached which corresponds with the mean latitude—60 deg. 3 min.—of the centres of the respective river basins. Now the rotary velocity of that parallel is 758.22 ft. per second, while the mean rotary velocity of outlet into the Artic Ocean is 538.16 ft. per second; hence 758.22—538.16=220.06 ft. per second, *increase* of velocity round the axis of rotation takes place during the transfer of the water from the outlet of the rivers in the polar sea, to the parallel referred to. The diminution of rotary velocity of the water in its course to the Arctic Ocean and the subsequent *increase* of rotary velocity being alike, it will be evident, without referring to previous demonstrations, that when the retrograde current arrives at lat. 60 deg. 3 min. the entire *compensating* energy has become neutralized. It will be evident also that when the retrograde motion reaches parallel 49 deg. 54 min., the rotary velocity of which is 220.06 ft. per sec. greater than that of the centre of the river basins, a *retarding* energy has been called forth of equal amount with the neutralized compensating energy of 91,111,578,300 foot-pounds per sec.

It results from the magnitude of the earth's present vis viva and the laws of motion referred to in the preceding article, that the retardation of one second in a century demands a continuous expenditure of mechanical energy of 37,909,059,765 foot-pounds per second. Hence the loss of 91,111,578,300 foot-pounds of vis viva per sec., which the earth suffers by the counteracting influence of the water circulating between the Arctic Ocean and the tropical seas, in the manner explained, will cause a retardation of 2.40342 secs. in a century. Adding the retardation of 1.42071 sec. previously established, it will be found that the river systems of both hemispheres call forth an amount of retarding energy capable of changing the length of a century 3.82413 secs. We have thus accounted for nearly one-third of the amount of retardation of the earth's rotary velocity which modern astronomy has deduced fram the apparent acceleration of the moon's mean motion. No reasonable objection can be urged against

our conclusions with reference to the return-currents, as it may be satisfactorily demonstrated that the water discharging into the Arctic Ocean by the Northern rivers, is not, during its return movement towards the equator, converted into vapor until it has reached a parallel much nearer the tropical seas than the one assumed in the foregoing calculations.

The investigation of the river systems of both hemispheres, and the ocean currents connected with the same, being thus concluded, the chief cause of the retardation of the earth's rotary velocity now claims our attention, viz.: the retarding influence called forth by the movement of the water of the oceans in the temperate zones, in the direction of the equator, to make good the loss produced by evaporation within the tropics.

It will be indispensable, before examining the result of this movement, that we clearly comprehend that, although the sea is composed of particles unconnected with the body of the earth, free to move in all directions in conformity with the laws of equilibrium, yet, owing to the small depth compared with the earth's diameter—proportionably not more than a sheet of cartridge paper bent round an ordinary terrestrial globe—and, owing to the varying depth of the ocean and the intervening continents and islands, the water of the sea is urged round the axis of rotation as effectually as the solid matter composing the body of the earth. Accordingly, water which moves from the temperate zones towards the equator through the sea retards the rotary velocity of the earth with as much energy as water confined in river beds moving in the same direction. The experiments with the dynamic register prove conclusively, that a given weight of vapor transferred in a given time from the equator in the direction of the poles cannot restore the retarding energy produced by an equal weight of water transferred in equal times towards the equator. Consequently if the whole quantity of water precipitated on the seas of the temperate zones is not evaporated within the parallels in which the precipitation takes place, a corresponding portion of the water thus precipitated must return to the parallels in which the evaporation was originally effected. Evidently, then, the main point of our inquiry is confined to the question, what proportion of the water precipitated on the seas in the temperate zones is not there again evaporated? It needs no demonstration to show that the quantity not evaporated must return to the tropical waters. In the absence of trustworthy experiments enabling us to determine the amount of evaporation and precipitation at sea, we must judge by what we find on extensive planes free from mountains and nearly on a level with the ocean. The Mississippi river basin probably furnishes a better comparison for the purpose than any other level plane of equal extent. It may be objected that the amount of evaporation on land is different from that at sea—a reasonable objection—but the difference will unquestionably be in favor of assuming considerable return currents towards the tropics, since the heated soil of river basins, and the increase of evaporating surface resulting from the numerous minute projections on the ground produce a more rapid evaporation than on the ocean. Regarding the amount of precipitation, it should be observed that the previously published tables are based on an annual average for the whole of the Mississippi basin of only 30 in. Considering that the rain gauges of the lower portion of this basin, which is nearly level with the Gulf of Mexico, indicate 60 in. for 12 months, it would be inconsistent to suppose that the amount of ocean precipitation between the tropic of Cancer and latitude 42 deg., a zone the mean latitude of which corresponds with the lower Mississippi valley, is less than the average of the basin of that river, viz., 30 in. Nor would it be consistent, as we have shown, to suppose that a greater proportion of the water precipitated is re-evaporated at sea than upon this basin, namely, 22.5 in., or 0.75 of the average rainfall of 30 in. per annum. Consequently we may, without fear of committing any material error, assume that the precipitation and re-evaporation on the oceanic zone between the tropics and the latitudes 42 deg. north and 42 deg. south, are the same as the mean observed on the entire Mississippi basin, viz., 30 in. precipitation and 22.5 evaporation. Accordingly the depth of water not re-evaporated, and, therefore, returned to the seas within the tropics, will be 7.5 in.

On this basis the accompanying Table has been constructed, and the retarding energy computed. The reason for select-

ing latitude 42 deg. as the mean limit of return currents resulting from precipitation is that, in the northern hemisphere, the seas extend but little beyond this latitude (fully three-fourths of the surface of the earth between latitude 42 deg. and the Arctic Ocean, consisting of land), while in the southern hemisphere, we have good grounds for assuming that beyond the 42d parallel, the precipitation and evaporation are nearly balanced. Regarding the accompanying Table, it will suffice to state that the increase of rotary velocity, 115.44 ft. per sec., has been determined by comparing the mean latitude of the oceanic zones referred to, and the tropical latitude $23\frac{1}{2}$ deg.; the rotary velocity of the former being 1277.48 ft., and that of the latter 1392.92 ft. per sec. A rate of 115.44 ft. per sec. is generated by a fall of 208.22 ft.; hence if we multiply this fall by the weight of water transferred to the tropics, we establish the fact that the total retarding energy amounts to 263,343,000,000 foot-pounds per sec. This computation, it will be observed, is based on the assumption that the retarding influence called forth by the return movement produced by precipitation in the temperate zones, ceases when this movement reaches the tropical zone. It is true that the motion of a certain portion of the returning water will extend to the equator, to fill the void already referred to, and before complete evaporation is effected; but, on the other hand, considerable evaporation takes place previously to reaching the tropics. Besides some allowance, though small, should be made for the tangential force imparted to the earth, from west to east, by the vaporous polar current. Again, the last 5 deg. before the returning water reaches the equator, produces scarcely any increase of rotary velocity, and hence no material counteracting energy. Accordingly, the result of our calculations recorded in this Table, cannot be far from correct.

Table of Oceans and Land between Latitudes 42° North and 42° South.

Oceans between the tropics and latitudes 42° north and 42° south.	Area in square statute miles.	Water transferred to the tropics.		Rotary velocity.	Increase of rotary velocity.	Retardation.	Oceans and land within the tropics.	Area in square statute miles.
		Cucic feet per second.	Pounds per second.	Feet per second.	Feet per second.	Foot-pounds per second.		
North Pacific Ocean....	8,697,000	4,794,400	$2,996\times10^5$	1277.48	115.44	$62,392\times10^6$	Land from equator to tropic of Cancer	9,982,900
North Atlantic " ...	5,406,000	2,980,140	$1,862\times10^5$	"	"	$38,782\times10^6$	Water from equator to tropic of Cancer...	29,156,000
South Pacific " ...	9,962,000	5,491,690	$3,432\times10^5$	"	"	$71,468\times10^6$	Land from equator to tropic of Capricorn..	8,560,000
South Atlantic " ...	5,256,000	2,897,440	$1,810\times10^5$	"	"	$37,707\times10^6$	Water from equator to tropic of Capricorn.	30,230,000
Indian " ...	7,387,000	4,072,190	$2,545\times10^5$	"	"	$52,994\times10^6$		
Total..........	36,708,000	20,235,860	$12,645\times10^5$	"	"	$263,343\times10^6$	Total area of tropics.............	77,928,900

We have now to consider the loss of mechanical energy resulting from the loss of heat generated by friction among the particles of the opposite currents of atmospheric air circulating between the equator and the poles. Unless some powerful process of compensation can be shown to exist, an additional source of retardation of the earth's rotary velocity resulting from solar heat, will be established. The practical mind at once rejects the prevailing notion that there is a perfect exchange of motion without loss of energy between the heated equatorial currents directed towards the poles and the returning cold currents directed towards

the equator. We have already pointed out the fallacy of the deductions of Laplace, attributable to his ignorance of the convertibility of mechanical and molecular motion. Our highest modern authority, likewise, ignores the loss of mechanical energy resulting from the generation of heat by contact and friction between opposite currents of air. Sir John Herschel (see "Outlines of Astronomy," page 153) says: "The constant friction produced between the earth and the atmosphere in the regions near the equator must (it may be objected) by degrees reduce, and at length destroy, the rotation of the whole mass. The laws of dynamics, however, render such a consequence generally impossible; and it is easy to see, in the present case, where and how the compensation takes place. The heated equatorial air, while it rises and flows over towards the poles, carries with it the rotary velocity due to its equatorial situation into a higher latitude, where the earth's surface has less motion. Hence, it will *gain* continually more and more on the surface of the earth in its diurnal motion, and assume constantly more and more a *westerly* relative direction; and when at length it returns to the surface, in its circulation, which it must do more or less in all the intervals between the tropics and the poles, it will act on it by its friction as a powerful south-west wind in the northern hemisphere, and a north-west wind in the southern, and restore to it the impulse taken up from it at the equator." We have already demonstrated that currents of air cannot augment the velocity of rotating bodies, and that rotating bodies cannot produce currents of air or augment their speed, without great loss of mechanical energy—owing to the fact established by the dynamic register, that a considerable portion of the motive energy is converted into heat. Consequently the augmentation of the rotary velocity of the particles of air composing the polar current, will be attended with great loss of mechanical energy during their course to the equator. It would be an insult to the intelligence of well-informed engineers to suppose that they need proof of the obvious fact, that, when the polar current reaches the equator, its rotary velocity is not so great as that of the circumference of the earth unless some other force than that communicated by contact with the earth's surface restores the lost energy and flagging velocity. It is susceptible of practical demonstration that so considerable is the loss of mechanical energy caused by the conflicting motions of the opposite atmospheric currents circulating to, and from, the poles, that, in the absence of some adequate force to restore the lost motion, the body of air returned from the poles would lag far behind the earth's rotary velocity at the equator, and that consequently a continuous easterly current, amounting to a tempest, would prevail in the tropical regions. By what means, then, is the force supplied which imparts fresh rotary energy to the returning polar current, and thereby prevents a perpetual easterly wind of destructive violence within and near the tropics? The average calorific energy of solar radiation within 30 deg. of each side of the ecliptic, is capable of evaporating fully 2 lbs. of water daily upon 1 sq. ft. of surface, or 25,000 tons on a square mile, during each diurnal revolution. Consequently the polar current in its progress towards the equator will be pierced by an ascending column of aqueous particles possessing the same rotary velocity as the surface of the tropical seas. The result is self-evident; the particles of air composing the polar current will gradually acquire, by contact during the onward movement, a rotary velocity equal with that possessed by the aqueous particles of the ascending column. The adequacy of the latter to impart the necessary rotary velocity cannot be questioned in view of the enormous weight, 25,000 tons per sq. mile, raised daily by evaporation. The observed prevalence of westerly winds (absurdly attributed to the action of "some force external to the earth") is readily explained if we consider the vast amount of rotary vis viva imparted to the atmosphere by the tropical vapors during their course towards the poles. Indeed, the force thus imparted from west to east is so great that, but for the loss of energy caused by the conflicting motions of the currents between the equator and the poles, a strong westerly wind would prevail in the temperate zones.

Having thus briefly examined the means by which the loss of mechanical energy resulting from the conflicting motions of the equatorial and polar currents is made good, and shown how the excess of rotary velocity of the tropical

vapors is utilized, we may now enter on the task of summing up the amount of counteracting force, and determining the consequent total amount of retardation of the earth's rotary velocity. The retarding energy exerted by the 78 rivers flowing towards the poles which do not discharge directly into the Arctic Ocean being 20,399,766,300 ft.-lbs. per second, while the water returned from the seas of the temperate zones to the tropical waters, as shown by the preceding Table, exerts a retarding energy of 263,343,000,000 ft.-lbs., it will be seen that the total counteracting force is 283,742,766,300 ft.-lbs. per second. Multiplying this sum by the number of seconds in a century, we determine the retarding force exerted in that time; and by deducting the product from the earth's vis viva, we obtain the necessary data for computing the retardation. Bearing in mind that the velocities are as the square root of the forces, we are thus enabled to determine that the retardation amounts to 7.48482 secs. in a century. The counteracting energy exerted by the *sediment* transferred by the southern rivers, has not been included in this calculation, on the ground that the solid matter carried in an opposite direction by the polar rivers, calls forth an amount of propelling energy fully balancing the counteracting force. As already demonstrated, the retardation produced by the river systems of both hemispheres, and the return currents connected with the rivers flowing towards the poles, amounts to 3.82308 secs. in a century. Adding this to the before-mentioned retardation of 7.48482 secs. we establish the fact that the evaporation caused by solar radiation, within and near the tropics, calls forth a counteracting energy, which retards the earth's rotary velocity11.3079 secs. in a century. Future researches will show that this amount is greatly underestimated. I maintain that solar influence subjects the earth to an amount of retardation many times greater than that inferred from the observed discrepancy between the mean angular motion of the moon and the earth's rotation. Careful examination of the foregoing calculations cannot fail to convince the competent that the retarding energies have all been greatly underrated. Again, the disturbing influence of the matter transferred to fresh localities on the earth's surface has been determined by calculating the mechanical energy abstracted during the increase, and imparted during the diminution of velocity round the axis of rotation. Evidently if we base the computations on the difference of the rotary vis viva possessed before and after the transfer a higher result is reached.

It will be objected that the earth's retardation cannot exceed the amount indicated by the apparent acceleration of the moon's mean motion. This objection would be unanswerable if the assumption were true that the moon moves in a non-resisting medium; but the emission theory of heat and light being untenable, we are compelled to admit that the ether is a vehicle capable of transmitting mechanical energy, hence amenable to certain mechanical laws. The solar calorimeter has proved that a sunbeam of one square foot section exerts a mechanical energy of 4690 foot-pounds per minute at the boundary of our atmosphere. Can we question that a medium capable of transmitting an amount of mechanical energy sufficient to raise a ton 2 ft. high in one minute, by a wave of only one square foot of section, shares with gross matter the properties of inertia and friction? It must be admitted, therefore, that the moon encounters resistance during its angular motion round the earth. Of course the diurnal rotation of the latter is likewise retarded, but the retardation is of a very different nature from that affecting the moon. The earth simply *rotates in the ether* (its orbital motion has nothing to do with the present question), the moon *moves through it*. Obviously the magnitude of the retarding energies will depend on the following elements: Extent of convex area presented by each of the two spheres, the mean rotary velocity of the earth's surface, angular velocity of the moon, rotary vis viva of the earth, and lastly, the moon's orbital vis viva. Demonstrations and calculations founded on these elements show positively that the moon's angular motion suffers a greater amount of retardation relatively, than the rotary motion of the earth. Hence, if the earth's rotation were not subjected to retarding influences within itself, the moon would lag behind. Its mean motion, instead of being apparently accelerated, would be actually retarded.

CONCRETE.

From "The Mechanics' Magazine.

The use of concrete is becoming more and more general every day, both in large engineering works and in house building, yet there is nevertheless probably more misconception about it than any other material used in construction. The points of most interest about it are,—the best materials for it, the proper proportion of lime or cement, its strength, and especially the *questio vexata*—the loss of bulk in mixing. We propose to say a few words on each of these points.

Three ingredients are absolutely necessary to form a good, sound, strong, and economical concrete, viz.: A hard, incombustible, and imperishable substance to form bulk; a finer material to fill up the interstices; and a cement or lime to unite the whole. The most suitable materials for the first ingredient are clean gravel, shingle, flints, stone chippings, broken pottery, clinkers, slag, brick bats, burnt clay, etc. It is, however, very important that the gravel should be clean and quite free from loam and dirt, otherwise it must be carefully washed and sifted. There is a great deal of misapprehension as to the proper size for the gravel, to give the best results. Some engineers and architects specify that no piece shall be larger than a pigeon's egg, others that no piece shall be used that will not pass through a $1\frac{1}{2}$ in. ring. The general idea seems to be that larger pieces injure the strength and quality of the concrete. This is a mistake—a lump of stone in the concrete is certainly stronger than it would be if it were broken up and cemented together again. The real objection to it is that if a barrowful of large stones is tipped altogether in a heap the interstices never get properly filled in with the ordinary shingle or gravel, and consequently large hollow spaces are left or are else filled in with sand and cement to the detriment of the quality of the adjoining concrete. A proper admixture of larger pieces, *if judiciously added*, actually increases the quality of the concrete, as there are fewer interstices to be filled with a given quantity of cement and sand. The larger lumps should be distributed; but this need not involve extra labor, as it is not necessary for the distribution to be uniform, it being only important to prevent the large lumps from being in contact with each other so as to form large hollow crevices. There can be no objection to a piece of stone weighing 56 lbs. and upwards being used, provided it is entirely surrounded by ordinary gravel and not adjacent to other pieces of a similar size. It might possibly be injudicious to use any lumps larger in diameter than half the thickness of the wall being built, and even these should be used sparingly. We are not advocating the use of large pieces of stone indiscriminately or in great quantities, but we maintain that a judicious admixture of them, instead of being injurious, is actually an improvement and ought to be encouraged. The strength of concrete depends more on the comparative quantity of cement compared with the cubic contents of the spaces between the stones, than as compared with the absolute bulk of all the ingredients. For this very reason *isolated* lumps improve the concrete by reducing the percentage of cavities—and for the same reason too large a quantity of lumps close together, depreciate the quality of the concrete by increasing the cavities.

In practice, the sand and lime (or cement) ought, *when mixed*, to be a little in excess of the quantity actually required to fill up all the interstices properly. If less is used, the concrete is not sufficiently cemented together; if more, it is not so economical as it might be. Lime and sand, and cement and sand, lose about one-third of their bulk when made into mortar, therefore the sand alone, before mixing, should be slightly in excess of the spaces to be filled.

The spaces between the stones in ordinary clean gravel or shingle have been found by experiment to vary from 32 to 37 per cent. of the gross bulk of the gravel; that is to say, it would require that quantity of water to fill up the interstices. It is, however, evident that it would be impossible to get in an equal quantity of any solid, such as sand, as it could not penetrate into every crevice absolutely to the points of contact between the stones, as water does. By a series of carefully conducted experiments, it has

been ascertained that the average quantity of sand that can be mixed with clean shingle without increasing the bulk, and therefore exactly filling the crevices as far as practicable, is 12 per cent. Any additional sand beyond this quantity increases the gross bulk of the mixed sand and shingle by the same amount. But when the same experiment was repeated with 40 parts of sand and 20 parts of blue lias lime, all mixed together with 100 parts shingle and wetted, the total bulk was only 125½. Now we know from previous experiments that when sand and blue lias lime are made into mortar in the above proportion, the resulting mortar is only .714 of the combined bulk of the original lime and sand; consequently 40 sand and 20 lias lime ought to produce 42¾ measures of mortar; but the total bulk was only increased 25½, therefore the remainder or 17¼ mortar must have found its way into the cavities of 100 parts of shingle. But as the bulk of the mortar was about the same as the sand it was made from, in this instance about 17 per cent. of sand must have gone into the interstices, or just about half the cubical contents of the spaces as ascertained by the quantity of water they will contain. We have no doubt that a greater quantity of sand could always be worked in, when mixed with lime and water and beaten up in the state of mortar, than in its natural state.

Experiments would therefore seem to indicate that one volume of sand is sufficient for five volumes of gravel, but in practice one of sand to four of gravel would be a better proportion, as the spaces would be in excess of the above results if the concrete were not properly rammed, and it is better to have too much sand than too little, as a deficiency affects the strength, while an excess only adds to the expense. We remember having seen cement concrete specified to be composed of 3 gravel, 2 sand, and 1 cement; but we fancy 4 gravel, 1 sand, and 1 cement, would give far better results, as the cement mortar in the latter case would have been half cement and half sand, and would therefore have had three-fourths of the strength of neat cement; whereas cement mixed with 2 parts sand has only half the strength of the neat cement, and with 3 parts sand only one third of the strength. The above relative strengths of cement and cement-mortar are not assumed, but have been generalized from a great number of experiments made on the tenacity of cement and sand mixed in various proportions. It is important that the sand should be clean and sharp; recent experiments indicate that the use of loamy sand reduces the strength of the cement-mortar by about ⅕.

The quantity of water required in mixing a yard of concrete varies from 25 to 39 gals., according to the quantity of cement and sand used, the larger quantity being required when the concrete is made very strong, such as 5 of gravel and sand to 1 of cement. About 5 gals. of the above are used up in moistening the surface of all the stones. Concrete ought to be turned over 3 or 4 times in mixing, and as little water used as is practicable. If it looks wet enough after it has been turned over once, too much water has been used, for it generally looks wetter each time it is turned, although no additional water is used. The concrete, when mixed, should be thrown into its final position from a height of 7 or 8 ft., or what is better still, well rammed after it is in position. This forces the gravel stones closer together, reduces the total bulk of the interstices, and brings the semi-fluid mortar to the surface, showing that all the cavities are properly filled.

Medina cement is inferior to Portland for concrete, possessing only about ½ the tenacity. It is useful to form a thin coating of quick setting marine concrete, the bulk of which has been made with Portland cement. It hardens rapidly, and prevents the rising tide from washing the slower setting Portland out, before it has had time to harden sufficiently to resist the action of water in motion.

The quantity of lime or cement usually used in concrete varies from a 5th to a 10th of the bulk of the other material. A 5th is strong enough for any purpose if carefully and properly made, while less than a 10th can scarcely be relied on. In foundations where the concrete is of great depth, and has to bear a very large super-incumbent weight, the lime probably ought to be as much as a 5th, but a 6th would generallly do for ordinary foundations, while a 7th is quite sufficient for backing to arches and retaining walls. In building dwelling-houses, warehouses, chapels, etc., the

concrete is made of Portland cement, and should not be less than 1 of cement to 7 of material, but good boundary walls have been made with 1 of cement to $9\frac{1}{2}$ material.

Before concluding we will say a few words on the disputed question of the loss of bulk that the materials undergo when mixed into concrete. Experiments have repeatedly been made to ascertain the extent of the loss, if any; but the results are by no means satisfactory, as some seem to show that only the lime is lost, while others show a loss of $\frac{1}{5}$ of the ballast in addition to the lime. But the experimenters only tell us how much lime was used to a certain quantity of what is vaguely described as ballast, without saying what proportion of sand there was in the ballast, and this will probably account for the discrepancies. The following experiments, never before published, were made recently while a quantity of concrete work was being carried out in some sea defences on the South Coast. The shingle used was perfectly clean and free from sand, and the sand was all sifted.

Experiment I.

Clean shingle.....	$62\frac{1}{2}$		
Clean sifted sand..	25		
Total ballast...		$87\frac{1}{2}$	made $78\frac{1}{2}$ concrete.
Blue lias lime.		$12\frac{1}{2}$	
		100	

In this instance, the sand being in excess, a portion of it equal to the cavities was absorbed, while the excess increased the bulk of the concrete. Here $87\frac{1}{2}$ parts of ballast made $78\frac{1}{2}$ parts concrete, the loss being 9 in $87\frac{1}{2}$, or $10\frac{1}{3}$ per cent. Had the sand been only 17 per cent. of the quantity of shingle it would all have been absorbed in the interstices, and the quantity of concrete would have been about equal to the original quantity of shingle: —thus 100 shingle and 17 sand would have made (with a proper quantity of lime) 100 concrete, and the loss would have been 17 in 117, or $14\frac{1}{2}$ per cent. This latter is an extreme case, and shows the maximum loss of bulk in the sand and gravel, in addition to the lime disappearing, that can occur in freshly mixed concrete. A further settlement of about 4 per cent. would probably take place during the setting, making a total maximum loss of bulk equal to $18\frac{1}{2}$ per cent. in extreme cases.

Experiment II.

Clean shingle...	$68\frac{1}{4}$		
Clean sifted sand	$27\frac{1}{4}$	mixed =	
	$95\frac{1}{2}$	$87\frac{1}{2}$	made $89\frac{1}{4}$ concrete.
Blue lias lime......		$12\frac{1}{2}$	
		100	

(which were in the same relative proportion as in Experiment I., viz., 5 shingle to 2 of sand).

In this second experiment the shingle and sand were first thoroughly mixed without any lime; the loss in bulk by the sand occupying the interstices was equal to about 12 per cent. of the gross bulk of the shingle alone, as referred to in the commencement of this article. The sand now filled the interstices and the lime was added; the concrete in this instance was about 2 per cent. in excess of the bulk of the mixed sand and gravel when *first mixed*; but after setting, the bulk would be about 4 or 5 per cent. less, *i. e.*, about 3 per cent. less than the bulk of the sand and gravel *measured when mixed together* without any lime, or 12 per cent less than the original bulk of the sand and gravel *before mixing*.

The loss of bulk therefore of the shingle and sand seems to vary in extreme cases from $18\frac{1}{2}$ to 3 per cent., according to whether the shingle is entirely clean and free from sand, or whether the interstices are filled with sand, and also as to whether the sand is less, equal to, or more than the interstices in the gravel or shingle.

This clearly shows that the loss of bulk can be accounted for theoretically without any mystery. There is no contraction of the solid gravel stones, and the concrete is never less than the clean gravel, although always less than the gravel and sand combined, *vaguely* called ballast in most experiments. The loss of bulk is due, first, to the loss of bulk in the sand and lime or cement, when mixed into mortar; secondly, to the quantity of mortar in the interstices of the gravel; and thirdly, to a settlement in setting. We have before said that sand and lime in the proportion of 2 to 1 make .714 of their united bulk of mortar; if the proportion is 3 to 1 the mortar only amounts to .63; with cement in any proportion from 1 to 1 to 3 to 1, the resulting cement mortar is

just $\frac{2}{3}$ of the original bulk. If then we know the proportion of gravel, sand, and lime, or cement, we can ascertain the quantity of concrete that can be made from them approximately, as follows, viz.:

Add $\frac{2}{3}$ of the lime and sand to $\frac{5}{6}$ of the gravel, and reduce the total about 4 per cent. for settlement.

We should not have dwelt so much at length on the above particulars, but as the use of concrete is extending, its characteristics ought to be understood.

SELENITIC MORTAR.

From "Engineering."

For some months past a series of careful and exhaustive experiments have been in progress at South Kensington, in order to test the value of a new kind of cement and mortar. This substance is the invention of Colonel Scott, R. E., and was referred to by us in our notice of the International Exhibition buildings on the 23d December last, as having been used in the construction of the French annexe. It has been named by Colonel Scott, selenitic mortar, and the process of production consists in mixing with the water used in the preparation of the mortar, a small quantity of sulphate of lime, in the form of either plaster-of-paris, gypsum, or green vitriol. These substances having been intimately mixed, the lime is added and ground with the water or sulphate into a creamy paste. The mixture is prepared in the pan of an ordinary mortar mill, in which the water and sulphate are first introduced, and subsequently the lime. After the lime has been ground for 3 or 4 minutes, the sand, burnt clay, or other ingredients are added, and the whole is ground for 10 minutes. By this invention, ordinary lime can be at once converted into a species of cement mortar which sets rapidly and well, and can be used for concrete, bricklayer's work, or stuff for plastering, at a cheaper rate than that made from lime in the ordinary way. From his experiments, Colonel Scott finds the use of sulphuric acid to give the best results, so that this substance is used in preference to plaster-of-paris or gypsum, although the latter materials will answer for all practical purposes. Sufficient acid is contained in plaster-of-paris to effect the necessary chemical change, and to prevent the lime from slaking, which in effect is the secret of the whole process. The lime, by this means, is enabled to take twice as much sand as when slaked, its fiery nature being brought under control. Any lime can be made selenitic by Colonel Scott's process, and the more hydraulic it is, the better are the results obtained with it.

The invention is not only applicable to cement manufacture and mortar mixing, but its use extends to brick making. A number of bricks have been made since the opening of the Exhibition, by Mr. Large's dry brick press in the pottery machinery annexe. These bricks are composed of 1 part lime to 8 or 10 parts sand or burnt clay, and they are found to be ready for use in about 10 days after pressing without being burned. It is found that these bricks do not swell as is ordinarily the case from the slacking tendency of lime when not made selenitic. The proportions adopted for various purposes are as follows: Mortar for bricklaying, water half a pail, plaster-of-paris, 4 lbs.; mix and add in the pan of the edge-runner 2 or 3 pails of water, a bushel of lime, and 6 bushels of sand; grind for 10 minutes. For mortar for pointing, water, plaster, and lime as before, and add 2 parts chalk, slaked lime or whiting, and 2 parts sand. For coarse stuff for plastering, same ingredients as for mortar, but coarser sand, and grind for five minutes only. For fine stuff for plastering, water, plaster, and lime as before, a bushel and a half of chalk and 2 bushels of fine mashed sand. For coarse stuff on lath add with the lime 5 lbs. of hair, which need not be previously beaten. For rough stucco, same as for mortar, but 4 bushels only of sand. Plastering on walls can be done by this process as 2-coat work, while ceilings can be floated immediately after the application of the first coat and set in 48 hours.

An examination of the walls of the

French annexe and some recent samples of work in the experimental yard at South Kensington, have shown us the thorough adaptability of this material to the various purposes to which we have referred. The cements are very quick setting, and they produce a very hard and finely finished surface.

Nature of Experiment.	Age of joint or sample in days.	Composition of Mortar in parts.		Breaking weight of joint or sample.
	days.		sand.	lbs.
Two bricks joined crosswise with selenitic mortar, giving an area of 20 square inches of joint.........	14	1 Medway gray lime..	3	255
Ditto ditto ditto	14	1 " " ..	4	327
Ditto ditto ditto	14	1 " " ..	5	340
Ditto ditto ditto	14	1 " " ..	6	339
Ditto ditto ditto	14	1 Lias lime	3	259
Ditto ditto ditto	14	1 "	4	144
Ditto ditto ditto	14	1 "	5	160.5
Ditto ditto ditto	14	1 "	6	172
Ditto ditto ditto	14	1 Portland cement...	4	217
Ditto ditto ditto	14	1 " ...	5	304
Ditto ditto ditto	14	1 " ..	6	206
Ditto ditto ditto	14	1 Lee's grey lime....	3	325
Ditto ditto ditto	14	1 "	4	336
Ditto ditto ditto	14	1 "	5	290
Ditto ditto ditto	14	1 "	6	303
Prism of selenitic mortar 2 in. × 2in. × 4 in. long, and 3 in. between points of support..................	209	1 Portland cement...	3	668
Ditto ditto ditto	209	1 " ...	4	476
Ditto ditto ditto	209	1 " ...	5	344
Ditto ditto ditto	209	1 " ...	6	190
Ditto ditto ditto	177	1 Barrow lime.......	4	740
Ditto ditto ditto	177	1 "	5	776
Ditto ditto ditto	177	1 "	6	698
Prism of Mortar, same dimensions as before, but not selenitic......................................	177	1 "	3	440
Ditto ditto ditto	177	1 "	4	338
Prism of selenitic mortar, same dimensions as before	230	1 Lee's grey lime	4	806
Ditto ditto ditto	230	1 "	5	722
Ditto ditto ditto	230	1 "	6	876
Briquettes of selenitic mortar, breaking area $1\frac{1}{2}$ in. × $1\frac{1}{2}$ in. = $2\frac{1}{4}$ sq. in..................................	167	1 Portland cement...	4	206
Ditto ditto ditto	167	1 "	5	149
Ditto ditto ditto	167	1 "	6	113
Ditto ditto ditto	132	1 Roman cement	3	232
Ditto ditto ditto	132	1 "	4	250
Ditto ditto ditto	132	1 "	5	124
Ditto ditto ditto	132	1 " ...	6	89
Ditto ditto ditto	166	1 Medway grey lime .	3	245
Ditto ditto ditto	166	1 " ..	4	147
Ditto ditto ditto	166	1 " ..	5	150
Ditto ditto ditto	166	1 " ..	6	108
Ditto ditto ditto	76	1 Halkin lime	3	128.5
Ditto ditto ditto	76	1 "	4	197
Ditto ditto ditto	76	1 "	5	99
Dilto ditto ditto	76	1 "	6	111

We give in the preceding table the results of a few experiments taken by us at random from the records of many thousands made under the superintendence of Mr. Gilbert R. Redgrave for Colonel Scott, in order thoroughly to test the efficiency of his invention. The early results were so remarkable that the Colonel was induced to repeat them over and over again, and to institute many others in order perfectly to satisfy himself of the correctness of his conclusions. The most searching trials, however, have only further demonstrated the importance of the invention, which is a thorough success and must prove invaluable in the constructive arts.

Samples of this cement were exhibited at the last Conversazione of the Institution of Civil Engineers, when a num-

ber of them were tested by Mr. Michele in his testing apparatus, and gave very satisfactory results.

As it is often found in practice that tiles bedded in Portland cement leave their setting, Messrs. Minton caused a series of experiments to be made with selenitic cement in order to test its adhesive qualities in this respect. A number of their tiles were joined together in pairs crosswise in the same way as the bricks, with two parts of ordinary Portland cement to one of sand. After allowing the joints to stand 14 days, a weight of 56 lbs. separated them, the cement in most cases coming clean away from the tile. With selenitic cement composed of 1 part lime to 5 of sand, the joint being 14 days old, it required a weight of 158 lbs. to overcome adhesion, and then the fracture took place completely through the cement, half remaining on each tile. With 1 of cement to 3 of sand, the breaking weight was 166 lbs., and with 4 of sand 165 lbs. ; the fracture in all cases taking place through the cement. These and the results given in the tabulated statement afford conclusive evidence of the superiority of the selenitic mortar over the ordinary compositions. We may add that a briquette of ordinary mortar composed of 1 part lime and 2 of sand, 6 months old, usually breaks at 70 lbs. or thereabouts.

THE NATURAL HISTORY OF PAVING STONES.

By PROF. WILLIAMSON, F.R.S.

From "Science Lectures for the People."

When, some century and a half ago, the first excavations were made into the lava masses that covered the ancient city of Pompeii, it was discovered that the streets of the city had been paved with blocks of lava from the adjoining mountain Vesuvius. You have probably all heard of Macaulay's apocryphal New Zealander, who, in some future age, when England has passed its zenith, and is once more become a desolate wilderness, is to sit upon one of the broken arches of London Bridge to sketch the ruins of St. Paul's. And if that topographer of the future, when he accomplishes the task that the brilliant essayist assigned to him, visits the city which tradition indicates as having been the ancient seat of manufactures in this part of the country—I mean the city of Manchester—he, if he has assistants with him and should make similar explorations in the streets of this city, will have to record the same fact that has been recorded of ancient Pompeii. Unexpected as the fact may be even to you, he will have to announce that the streets of the city were chiefly paved with lava from an adjoining mountain.

Now before I demonstrate this apparently paradoxical statement, I must call your attention to the fact, which probably most of you know already, that there are two very different kinds of rocks found in the interior of the globe. There are, first, those that have been produced by volcanic fire—lavas—of an endless variety of sorts. There are, secondly, what are called the stratified rocks, that have been produced by the action of water. If you see a muddy pool deposing layer after layer of mud, and if when this mud subsequently becomes dried up, you proceed to examine the muddy deposit, you will find that it is arranged in layers. Now this deposit is on a small scale an epitome or picture of what is taking place on a gigantic scale in lakes and seas throughout the entire world. Every part of the world has been under water at one time or another; and the deposits that have been produced during countless ages have given us what we call the "stratified rocks." But you will probably like to have a proof of everything that is said from this platform. You may ask—How do you know that these deposits have been formed by water?

I wont dwell upon the subject ; I will merely say that where we find oysters, and mussels, and cockles, and crabs, and lobsters, we are pretty safe in affirming that the deposits which enclose the remains of those marine creatures must have been formed somewhere in the neighborhood of the place where these marine creatures lived. And so the marine remains of fossils that we find in these rocks clearly testify to the fact that the rocks in question

were formed by watery agency and under water. But you say, in the second place, even supposing we accept that proof as satisfactory, what evidence have you to give us that the other rocks were formed by fire? As this will be the special subject of a portion of my lecture to-night, we will take a little more trouble to demonstrate this fact to you, and make it plain.

The first photograph that I will show you is one from a drawing in a work recently published by Professor Silvestri, a work in which he gives an account of the changes that have taken place during the last few years through the eruptions of Mount Etna. Here you have a view of the summit of Etna; the central peak is here. I need scarcely tell you that you are looking down upon it as if from one of the balloon posts, about which we have heard so much latterly. All these round knobs that stand out so numerously and so prominently are so many craters that from time to time have burst through that mountain. There are hundreds of these craters, and a large number of them constitute even decent-sized volcanic mountains, scattered round the slopes of Mount Etna. Then these large black spaces, to which I would particularly call your attention, are areas where the lava has burst through some of these craters. Of course it has filled up the crater through which it flowed; but, in addition to filling the crater, it has overflowed its summit, and spread itself out in broad table-like areas over the sides of the mountain, and over the surrounding plains. Now, we have here an illustration of the kind of thing that these volcanic mountains exhibit. You may be somewhat surprised if I tell you that those slopes of Mount Etna are scarcely more pierced by craters and encompassed by deposits of lava than Wales is, in our own immediate neighborhood. There has been a time when Wales was almost as much disturbed by volcanic fires as Sicily is now. If you were to take a geological map of Wales, you would see that it is studded all over and in every direction with little red spots. Those little red patches are colors employed by geologists to indicate masses of ancient lava. Wales abounds in these masses. We find them on every hand, and it is to some of them, in the first place, that I shall have to call your attention to-night. I will show you a section of a part of Wales where we have volcanic rocks, and stratified or aqueous rocks, side by side, or rather, the one within the other. A section, you will understand, is that which you would have if I were to cut a Dutch cheese in two, and show you the cut side of it. If the Dutch cheese had happened to have been made of layers, piled upon one another like a pile of sandwiches, you would then have the edges of the layers revealed to view. But here, instead of sandwiches, we have a series of layers of stratified rocks; and, in the middle of them we have a great mass of volcanic lava. This is a mass of ancient lava from one of the Welsh mountains, with an unpronounceable name. I dare not venture to utter it. I should only fail; because, as you know, it is not easy to say which are consonants and which are vowels in the Welsh language, unless one is trained to it, which I was not. These are slate rocks. You will observe they are arranged in sloping layers, but these layers were originally horizontal. The reason why they slope upwards is that the volcanic fires which accompanied the outburst of this lava mass has driven up these stratified rocks, tearing them asunder, whilst the lava has forced its way through. We have several reasons for affirming that this lava was once fluid. You will observe that the lava has not only broken through these stratified rocks, but flowed upwards and downwards in all directions, filling cracks and crevices, which would not have happened had this lava not been fluid. Before I give you another section illustrating to you this action, let me show you a section of Snowdon itself cut in two. You shall also see the summit of Snowdon, which a kind friend who is in the room has brought to us. Then we have here a section of Snowdon. Here you have the extreme summit of Snowdon—the point to which many of you probably have been. You will observe that there are several series of rocks following each other. Now what, in the first place, are these purple-colored layers at the base? (The colors are merely conventional, for the purposes of the diagram.) They are beds of slate rocks. These yellow-tinged parts above them represent enormous masses of lava. Now, this mass of lava was once continuous over many miles of district. The reason why it is now isolated is this: after

spreading over many miles of district, it has been subjected to the action of currents of water when the whole was under the sea. These water currents have scooped out deep valleys, and swept away an incalculable number of square miles of solid materials. Parts of Wales that were once thousands of feet higher than they are at the present day, have been completely cleared away by this watery action—by what is technically called "denudation." This accounts for the interrupted character of these masses of deposit. The summit of the mountain is a mass of volcanic product; not lava, but ashes. It would appear as if the volcanic outbreak which had covered this part of the country with this peculiar kind of volcanic rock, had been followed by some outburst such as you meet with in volcanoes of the present day, in which an enormous quantity of volcanic ash has been deposited; and some of what escaped removal by denudation now constitutes the extreme peak of Snowdon. The next picture will show the peak of Snowdon as it now is. The difference between the present and the past is very considerable. I do not mean to say that the cairn is a volcanic peak ; it is not ; but the material upon which the wonderful cairn is erected is volcanic ; it is made up entirely of volcanic ash. So that we have in Snowdon three distinct masses of material—the volcanic ash at the top ; a mass of lava in the middle ; and the water-derived slate rocks at the base. In the diagram I showed you just now, you saw a broad red band crossing the picture obliquely. Now this band is another kind of volcanic rock, and of more modern date than the others. You ask, "How do we know that?" Well, I think we may safely venture to say that that which goes through another thing, has come there subsequent to the time when that which it penetrates first existed. These rocks, you perceive, have been already deposited when some huge volcanic crack has been formed in them, and volcanic material has come up and filled that crack. Here we have evidence of successive outbreaks of volcanic action. Now I will show you the proof that this volcanic action was accompanied by heat. I think I have said enough to show that this material must have been fluid. The reasons why we conclude that that fluid must have been in a heated state like lava, are these: In the first place, wherever the lava has come in contact with any other kind of rock, it has entirely altered the character of that rock. If it has come in contact with coal, it has burned that coal into cinders; if it has come into contact with limestone, it has burned that limestone into marble; and if it has come into contact with slates, it has altogether altered the character of those slates, and given them a different appearance. I will show you an instance proving this point. The picture that I am now going to exhibit to you is a section of another part of Wales, derived, as most of these sections are, from the very able report on the Geology of Wales, by Professor Ramsay, and which was published in the Memoirs of the Geological Survey of England.

Here we have a series of slate rocks with a dyke of lava running through them. Here is a fragment of slate torn off from these rocks and imbedded in the lava. You will observe that the appearance of the slate immediately above and below the lava is altogether altered. The difference is this—one portion of the slate cleaves easily into roofing slates; but the layer in immediate contact with the lava has been so altered by that contact that it refuses to be so cloven. Now you have here a clear proof that the contact of the lava with the stratified or aqueous rocks has made an entire change in the structure of those rocks; and we know from examination that all these changes, wherever we find them, are precisely the phenomena that would result if the same rocks were exposed to the action of heat.

The next point that I will speak of is the more special subject of the lecture tonight. I am going to tell you about paving stones. As Professor Roscoe has intimated to you, it is a somewhat unpromising subject; and I confess I was rather disposed to approach it with a little fear and trembling. In Manchester, as I learn from our friend Mr. Stott, who has charge of this department, we use different kinds of stones for paving. I have here three stones of one kind, and several stones of another kind. Before going into details, I must remind you that we have in Manchester an ancient civilization and a modern civilization. If you go along the back streets of Ancoats and other parts of the town, it will be desirable, especially if the day be wet, to take care to have thick

shoes, because walking in thin shoes on the rounded boulder stones with which those older streets are paved is somewhat uncomfortable work. But our civilization has made our more modern streets very different. You know that they are paved with those square stones which I think are technically call "sets," stones which make a magnificent paving. The only complaint we hear about them is when our authorities do not supply the streets with quite sufficient water, and then the gentry who ride their horses or drive their carriages are a little disposed quietly to complain. But this is only one very insignificant feature of these stones. It is true they are apt to become a little slippery in dry weather; but on the other hand, they are exceedingly durable, and being durable they are eminently fitted for the purpose of the tax-payer, whatever they may be for the equestrian. I learn from Mr. Stott that we obtain these "sets" from three localities. Here is one stone that is obtained from Penmaenmawr. Here is another stone that has been obtained from the Clee Hills in Shropshire; and here is a third stone that is obtained from a part of Carnarvonshire, from the neighborhood of a place they call Glynnog. What are the rocks at these three localities? The Penmaenmawr and Clee Hill stones are very similar in their essential qualities; they are lavas, closely allied to the form we commonly call basalts and greenstones. I won't enter into the minute distinctions of these stones. I am not about to bewilder you by the wonderful chemical formulæ that my friend behind me (Dr. Roscoe) could favor you with, in describing the chemical composition of these stones; that would be out of my reach and line. Neither will I trouble you much with minute distinctions between one kind of basalt and another. There is an endless series of these distinctions that would perplex him still more to identify all the varieties when he saw them. All I have to do with them to-night is, to say that there are many kinds of lava, whether we choose to call them basalts or greenstones, or felspars or porphyries, or by any other of those mineralogical names which are employed to distinguish them. But we can draw a broad distinction between basalts, an ancient kind of lava, and granites, which are also an ancient kind of lava, but a very different one. Let us see what this Penmaenmawr stone is. It is a lava very similar in its essential composition to the lavas of modern times. Let us see what sort of appearance these rocks present as seen in a photograph. I have here two photographs of Penmaenmawr, a place that probably many of you have visited. One is a view from the north side, and the other a similar view from the south side. Here you have Penmaenmawr as it appears from the south side.

You observe that we have here a sloping plain. Now this plain consists chiefly of stratified rocks of various kinds. But you notice that Penmaenmawr is a huge rocky mass that rises up out of the plains—a huge boss. Now let us see the other side of Penmaenmawr. When viewed from the opposite side, it presents precisely the same features as before. Here you have Penmaenmawr as seen from the village itself. You observe that from this side you again have a large plain, made up of stratified rocks, with this immense boss of lava that has been forced through from below. The section I am about to show you is from the very heart of a mountain called Mynydd-maior. It consists of substantially the same rocks as Penmaenmawr. Now notice the stratified rocks. They have been thrown into almost vertical positions by the outburst of this lava. When the denuding currents have swept over that country—as I have told you they have done, again and again, through countless ages—they have removed all those portions of the rocks that were softer than others; they have yielded to the action of the water, whilst the harder rocks have resisted it. Now this lava being harder than the stratified rocks, has resisted that action; and, therefore, it stands out like a huge boss from the surrounding plain, precisely in the same way that we have seen that Penmaenmawr stands out from the plain surrounding it. It is simply because this crystalline lava is very much harder than the rocks around it that it stands in this fashion; it has resisted the denuding action; the other rocks have yielded to that action. Here then we we have a clear illustration of the nature of the rock of which Penmaenmawr consists, and which we are using to a very considerable extent for the purpose of paving

the streets of Manchester. We will now leave Penmaenmawr.

Let us next see what we have got in the Brown Clee Hills. Mr. Stott informs me that the Clee Hills stone will serve our purpose better than the Penmaenmawr stone. He believes it to be a harder stone. But when we examine the conditions under which it was formed, we discover that it is substantially the same thing we have had before. Here you have a section of the Clee Hills. At the base we have a limestone, similar to that which you have in the hilly districts of Derbyshire. Then we have here the millstone grit—that coarse grit—stone found in the hills behind Oldham and Rochdale. Then, at the upper part, we have a coal field, furnished with seams of coal like those that we find in this neigborhood. But this red band running up through the centre of the section, and overflowing right and left, is really lava, very similar to what we have seen at Penmaenmawr, a crystalline basalt, which is spread out over a very considerable area, forming an extensive moorland district; and it is from this district that this Clee Hill basalt is now being brought to Manchester. Thus we see that the phenomena attending the formation of this Clee Hill basalt are precisely the same in all essential features as those that have attended the formation of the basalts in Wales.

We have now to look at the third stone. You are all more or less familiar with the name of granite. Granite has unquestionably been an ancient lava; but it has been rather different from modern lavas in a variety of secondary circumstances. We see very clearly, first from its composition, and second from its microscopic structure, that it has not been formed under the same conditions as the ancient lavas with which we are familiar. The probability is that it has been formed under greater pressure. Whether that pressure has taken place deep in the interior of the earth, or whether it has taken place, as some suppose, under a deep ocean, we have no means of knowing. But there are many minor and secondary features about it which indicate that the conditions which make granite different from other stones, have resulted from an enormous pressure. But then we have two kinds of granite. Common granite is made up of three minerals, known by the respective names of quartz, mica, and felspar. But the particular variety which I hold in my hand, is that known by the name of syenite; and it differs from other granite inasmuch as the mica of ordinary granite is replaced by the crystals called hornblende. This is not a matter of any very great consequence to us, except for this reason, that the hornblende being somewhat harder than mica, we may fairly expect that the syenite may give us a harder paving stone than the ordinary granite. We will see what this syenite is like when at home. Here is a section which exhibits to us the locality from which this syenite is obtained. In it we again observe that we have the stratified rocks thrown upon end. The fact is, these stratified rocks in Wales, as elsewhere, have been twisted and twined about almost as easily as you could twist and twine about layers of cloth or brown paper. The forces with which nature has altered the condition of these strata, have been so gigantic that any resistance these rocks could afford has amounted to very little indeed. This syenite, you observe, presents itself to us under precisely similar conditions to those we have seen in the case of basalt. It comes up from below, filling a huge crack; and if we examine the sides of the crack we shall discover that the heat of the fluid mass of syenite has altered the rocks just as the basalts and other lavas altered the stratified rocks.

We will now leave these "sets" and examine an altogether different branch of our subject. We must turn to the ancient Manchester paving, and this brings us to the boulder stones. We have to take into consideration two or three circumstances in connection with these boulder stones. I am informed by Mr. Stott, that in the olden time, when we were in the habit of importing boulder stones for all the streets of Manchester, they were chiefly brought from the sea coast of Cumberland. If you go to the sea coast, either of Cumberland or of any other land, you will find that it is frequently made up of rounded stones, anything but agreeable to walk upon; almost worse, if possible, than the rounded stones with which your older streets are paved. You might be disposed to imagine that all these rounded boulder stones had tumbled down from the cliffs above, and simply been rounded by the action of the

water, by the waves beating upon them year after year and century after century. And in the case of many of these boulders you would undoubtedly be right in so surmising. I don't know much about the Cumberland coast, but I could take you to the Yorkshire coast, about which I do know something, and could show you there precisely similar phenomena to those which appear on the Cumberland coast ; and we have every reason to suppose that the essential conditions are pretty much the same in the two localities. When we visit these coasts, whilst we discover a large number of rounded stones derived from rocks forming the adjacent cliffs, we also discover mixed up with them a very large number of stones that are not to be found *in situ*, as we call it, that is in their natural position, within miles from us. Here, then, we clearly have to seek out some agent that has assisted the sea. There has evidently been some other power at work that has brought boulder stones to that Cumberland coast that were not there originally, and that were not derived from the strata of the adjoining cliffs. We find there granites and lavas, and an endless variety of other rocks that were not originally derived from the Cumberland hills at all ; they have been imported into that district and subsequently re-imported from that district to Manchester. Now whence have these other stones come ? It will simplify the matter, as the Irish song says, "altogether entirely," if we call your attention to a Manchester brick-field. You may ask, what on earth can a Manchester brick-field have to do with Cumberland boulders and the paving of Manchester streets ? More than you would imagine at first sight. If I take a walk with you to a Manchester brick-field, we shall discover that we are most interested in precisely that part of the field that will be the greatest abomination to the brickmaker. The brickmaker likes the nice, smooth, soft clay, without any stones in it, which to the geologist is about as stupid a part of the field as he could have. The geologist, on the other hand, likes to find a place that is full of gravel and sand, and huge boulder stones of every shape, and sort, and size—the very abomination of the brickmaker. I have here certain boulder stones that were taken from a Manchester brick-field. What have I in my hand ? A block of granite, which I carried painfully and laboriously one day from a brick-field in the neighborhood of Ladybarn. It is a mass of granite, rounded just like the rocks on the Cumberland coast. That granite has been transported from a considerable distance, because we have no granites nearer than Cumberland. The nearest granite we have to this locality is that of Shap Fell, in Cumberland. The granite from Shap Fell is a very remarkable granite, from the large crystals of flesh color which distinguish it. I have here, from this same brick-yard, a piece of Shap Fell granite. Why, I could swear to this piece of granite all the world over, as a man would swear to the face of his own wife, wherever he met with her. The features of it are so remarkable that you could not mistake it, if you knew what Shap Fell granite was. Now this Shap Fell granite, rounded and water-worn, has been brought to a Manchester brick-yard. How has it got there ? I have here another boulder. There is nothing particular about the appearance of this boulder, except that it is a piece of limestone that never "grow'd"—if I may apply Topsy's word—in the neighborhood of Manchester. It, like these other stones, has been brought to Manchester from a distance. But it tells me another story. It has another tale to record. I see that this surface is grooved, as if covered with the marks of a file. I turn it round to the other side, and I see that it is filed and grooved in like manner; but these grooves are not parallel with the former grooves. Here is a second flat face. It is very evident that in some way both these faces have had a good scrubbing, that has involved something more than a mere washing of the face. I dare say we have some keen reminiscences of the sort of scrubbing we used to get from the nurse's hands with rough coarse towels ; but that is nothing compared with the scrubbing these stones must have had. There has been an action which has flattened that surface and grooved it at the same time. We want some agency that will do all these things together. You will remember that when my friend Professor Huxley lectured here at the beginning of this series of lectures, he pointed out to you in a very clear and prominent manner, how absolutely necessary it was that any theory that was propounded to explain a multitude of phenomena should "go upon all fours;" that

is, it must be equal to the explanation of all the several isolated and detached facts that the theory is intended to explain. Now we want a theory that will explain all these things. We want a theory that will mix together rocks of all kinds, that will mix them up with clays and with sands, and with an endlessly varied set of materials. We want a theory that will make some of these rocks round and grooved and streaked. We want a theory that will explain why some rocks that are transported are as angular and as sharp as this specimen. In order to give you such a theory, I shall have to carry you half way across Europe. I will begin by taking you to Switzerland, and if you have as pleasant a voyage thither to-night as I had some months ago, I shall envy you the repetition of my enjoyment. Here is a photograph I took in one of the loveliest scenes in all Switzerland. Here you have the Mer de Glace, that great stream of ice which has been celebrated in almost all ages as one of the loveliest spots in Switzerland. The Mer de Glace belongs to that range of mountains of which the peak of Mont Blanc is the centre, and it is only a few miles away from that great mountain. This is a glacier. What do we mean by that? Those mountains which you see on all sides of the glacier are within the limits of perpetual snow; summer and winter, wherever there is a ledge upon which the snow can rest, it remains unmelted. This accumulation of the snow would in time entirely hide and bury the mountains, unless nature had provided some way for getting rid of the surplus. She has provided such a way. The pressure of the snowy mass on the upper parts, forces the lower snow down into the valleys. Then that snow, partly under the influence of the intense cold, and partly under the influence of the pressure to which the particles are subjected, becomes re-frozen, becomes consolidated, not into snow, but into a mass of solid ice; and by a wonderful series of changes, which my time will not allow me to explain, this icy mass flows down the valleys of these Alpine mountains, fitting itself to the various curves, to the widenings and narrowings of these valleys, almost as if it were a fluid. Indeed, so wonderful has been this peculiar power of the ice to adapt itself to the shape of the valleys, that the late Professor James Forbes, of Edinburgh, arrived at the conclusion that ice, hard as it appears to be when you are skating over it, must have possessed a certain property of viscosity, a certain kind of fluidity which enabled it to adapt itself to the various contours of the valley. Professor Tyndal, however, has given us a better explanation. He shows us that this downward steady movement is really accompanied by a crushing process, instantaneously followed in each atom by what he calls re-gelation, which means in plain English, freezing over again. The point we have to deal with is not this regelation. We may take the movement of the glacier as an accepted fact. These glaciers move from the higher valleys into the lower ones at a very slow pace, but one which is capable of being measured. But what takes place as they do so? These magnificent mountain peaks, composed in this instance chiefly of granite, are being continually disintegrated by the cold of winter, by the rain, storms, and various atmospheric agencies that affect the surface of the globe. Huge fragments come tumbling down from above, and of course these fragments fall from the ice. You will see running along here a band of rubbish that has fallen from above. You will see along here another band of rubbish that has fallen from above on the opposite side. The next photograph is one I took of the same spot in the immediate neighborhood of what is called the *moraine*, or, in other words, this band of rubbish. Here you have the mountain slopes that we descended. We crossed over these huge rocks. Here you see the ice-slope which we had to climb in order to get upon the glacier. You see here what kind of materials the moraine consists of. The whole of this mass of rubbish is resting, not upon the ground, but upon the ice, so that, as the ice moves, it carries all these rocks along with it, just as easily as you would carry your hat upon your head, and if it is one of the chimney-pot hats, I venture to say, an enormous deal more easily! This is what is called a lateral moraine, one running down each side of the glacier. There are other moraines. The next photograph that I will show you is from another glacier in the Chamouny valley—another of the Mont Blanc glaciers; but it shows a different part of the glacier. This is a very instructive picture to those who have

not visited the real scene. Here is the lowermost part of the ice; here is the cavern from which the water issues—there is always a torrent of water rushing down —and here we have what is called the terminal moraine. You will understand that when these masses of ice come down from the cold valleys above into the warm valleys below, the ice necessarily melts. Were it otherwise, those splendid scenes would become simply one sheet of polar ice. It melts, but the stones that it carries won't melt; consequently they have to stay there. As the ice melts, these stones drop down; and here you might almost imagine that you see them in the very act of dropping. These are stones that must have fallen almost the very day that I was there. Here is a glacier covered with ice; here are all the stones that form the moraine; here is the melting ice breaking off in blocks, and, as the ice breaks off and melts, the stones that break off with it tumble down as you see here. Now, you observe that in this way we have brought down to the lower valleys enormous quantities of material that lately had their home on the peaks of the mountains and in the valleys above. In this way we see that the glaciers not only receive from the mountains on each side immense masses of rock, but that they carry these masses of rock along with them down to the lower valleys. There is no doubt whatever that a very large quantity of material that we now find spread over the surface of the globe has been conveyed in this way.

But this alone would not account for the phenomena of our Manchester brick-fields. We want something more. We have evidence clear as the sun at noonday, that the material of which our Manchester brick-fields, and the brick-clays over a great part of the world, are similarly composed, have been brought thither by water. They have been deposited under water. We frequently find sea shells in them. We have the clearest evidence, I repeat, that these remains have been accumulated under the sea. Unless we can bring our glaciers in some way into contact with the ocean, our theory will not fulfil Prof. Huxley's requisition—it won't "go upon all fours." Let us see if we can find proof of that contact.

We will now transfer ourselves from Switzerland to Smith's Sound, in the Polar regions. Here is a drawing I have copied from one of Dr. Kane's sketches. Here you have what is intended for the sea. If you saw it in daylight, it would be a proper sea green. Here you have the rocks and lofty cliffs that surround the part of the country in which the phenomena I am about to explain exist. In the extreme winter these masses of ice extend right across the Sound, from side to side. As the summer approaches, the central ice breaks up speedily, and floats away; but long belts of ice hold their ground around the coast for a considerable part of the year, and sometimes they fail to break away from one season to another. Now these blocks, or masses of ice, technically called "ice belts"—because they belt round the coast—receive masses of rock in precisely the same way as the glaciers did in Switzerland. Thus we see that these blocks of ice would carry away with them blocks of stone, if any circumstances occurred to detach the ice from the land. The detachments take place perpetually, and they carry away with them these blocks floating upon their surface. They are huge ice-rafts, which sail southwards, impelled by Arctic currents. But this is not all. We have some glaciers in these polar regions, of precisely the same nature as those of Switzerland; but, instead of the polar glaciers being comparatively diminutive—$\frac{1}{4}$ or $\frac{1}{2}$ a mile across—the great Humboldt glacier is 50 miles across, from one side to the other, and yet that Humboldt glacier, which comes right down into the sea, is bringing stones along with it in precisely the same way as the other glaciers. Now, with such prodigious masses of stone-covered ice as this existing in the northern seas, you will not wonder that from time to time icebergs of the most gigantic size are met with floating out of those northern bays and straits. Remember that what are called icebergs are merely either fragments of this belt of ice of these Arctic glaciers broken away, or portions of that huge mass of ice which in winter covers the whole of those regions —when you see that these ice formations exist on so gigantic a scale, you will not wonder that icebergs are met with in these seas, sometimes a mile in extent. If you realize that, when you have an iceberg of this size, it floats with its summits 200 or 300 ft. above the sea, and that it sinks below the water some 6 or 8 times its elevation, I think you will

readily understand how that floating raft would be able to carry a very considerable slice of Penmaenmawr upon its surface! I have here a picture of one of these floating rafts copied from Dr. Kane's book. I have represented it as well as I could. Here you have the ice, which has upon its surface huge blocks of solid rock. This was sketched by Dr. Kane as he saw it floating away into the southern regions. It is an exaggerated example ; we do not usually see the rocks so huge in proportion to the size of the raft, but it will give you an idea of the kind of transporting power these ice rafts have.

Now let us see how all this applies to English scenery. I have told you that the glacier moves steadily down the valley. You saw from the diagram that the glacier is cut up by deep fissures, called crevasses, that go down frequently to its very bottom. The stones that appear upon the surface of the glacier fall into these crevasses, and at the bottom they become entangled in considerable numbers in the solid ice. Many of them are angular. But you will also understand that if that vast mass of ice, filled with stones, is moving steadily downward over the rocks of which that valley consists, those stones will act like the teeth of a huge rasp; that they will plough, just in proportion to their size and sharpness and hardness, deep grooves in the rocks along which the ice is travelling. The stones themselves, being imbedded firmly in the ice, will scratch and scour over the rocks over which they move ; and this is precisely what we find that they do. Sometimes the ice retreats, leaving behind the smooth and polished rocks, over which it formerly travelled ; the changes of the seasons frequently lead to its doing so ; the glaciers not unfrequently recede up the valleys in hot seasons and come down again in cold ones. When the ice recedes we see that the rocks are scoured and grooved and polished in the way we should expect them to be. But if they receive this rough sort of treatment, what might we expect to be the result upon the teeth of the rasp? Workmen know perfectly well that when they use their files upon hard metal the angles get worn off. It has been so here. We could readily understand that if this stone was imbedded in the ice, and formed one of the teeth of our great Arctic rasp, that its surface might well be flattened and grooved with longitudinal grooves. Here, then, we have an agent capable of producing grooves. Then, if these icebergs float upon the ocean, carrying rocks with them, they will travel southwards, carried by currents, and, as they come into warmer regions, they will share the fate of the Alpine glacier. Floating upon the sea does not save them; they melt little by little, and as they melt, the rubbish that they are supporting falls to the ground. The fact is, we have here a grand Arctic Limited Liability Carriage Company! and it is one in which the liabilities, in a financial sense, are at a minimum and exceedingly small, whilst the transporting power is at its maximum, or exceedingly great. If we were shareholders in a limited liability company, these would be just the results that we should like to attain to if we could. Inasmuch as the floating rafts cost nothing, it is of no consequence to the company that they melt, and that whatever they carry goes to the sea bottom. If they were bringing our trunks from the Arctic regions, we should find out the difference between them and a good old wooden ship. But they melt, and whatever they sustain, trunks or stones, goes to the bottom. The result is that large portions of the sea bed are being strewed over with blocks of stones — angular blocks, rounded blocks, sand, rubbish, every conceivable kind of produce that those northern mountains furnish is being gradually brought southward, and scattered over the bed of the Atlantic at the present day. And precisely similar phenomena were taking place during one of the latest of the geological periods when nearly the whole of our island was under the sea. There was a time, comparatively recent, geologically speaking, when our island was under the sea, but when the mountains of Wales and Scotland stood out like islets from the Arctic ocean. The great valleys of Snowdon were filled with these glaciers. If you go up the pass of Llanberis, you will see on every hand the indications of the fact in the rounded rocks, and in their scored surfaces, that abound on each side of the road. A little above the village you see them beautifully exhibited ; and in the same way throughout in the district of which Snowdon is the centre, you have

these indications of glacial action so numerous and so clear, that not a shadow of a doubt remains that the Snowdonian valleys, as well as the valleys of Cumberland and Scotland, were, at the time of which I am speaking, filled with ice glaciers. Now all these glaciers—along with others coming from hundreds, not to say thousands of miles away, as well as from mountains in the immediate neighborhood—brought their produce to the same bed of the ocean, and as it was all tumbled down into one common mass, you find materials in the shape of mud and sand as well as coarser materials, including both rounded and angular blocks, accumulated in the same sea bed. Now I think you will see that I have brought before you an explanation that fully accounts for the miscellaneous kind of admixtures that you find amongst the sand, and clay, and gravel beds whether of a Manchester brick-field or of the coasts of Cumberland and Yorkshire.

Ladies and gentlemen, I have now finished my task. I have endeavored, I trust not altogether unsuccessfully, to show you that in the natural world there are no objects, however common and familiar, that cannot reveal an interesting story, if we are but intelligent enough to question nature in a right manner. Many of you are occupied with manufacturing pursuits, and, from time to time, your workshops receive the visits of strangers, who look with intelligent interest upon the processes in which you are engaged, and upon the final products of your labors. I invite you, in like manner, to visit nature's workshop. She, too, is a fellow-laborer with yourselves; only, unlike you, she needs no rest, but works on, with untiring energy, day and night, summer and winter. She usually toils so noiselessly that few men know the vastness of the forces at her command. When we float idly upon a summer sea, or recline in some sheltered nook, watching the tranquil glories of a July sunset, we reck little of the fearful energies that underlie the present calm. It is only when nature rouses herself, like some angry lion, that men recognize her terrific powers. It is when the reeling earth is shaken by the earthquake, and cities crumble into dust; when the volcano belches forth its showers of ashes and streams of liquid fire, hiding the prostrated ruins from the eyes of men; when the flashing lightnings and the grand roll of the thunder inspire the stoutest hearts with wonder, not unmixed with awe; when the stormy ocean and the flooded river inundate the land, tossing man's proudest works, like playthings, from their surface, and hurling them to destruction, then it is that we learn something of nature's power. Yet these forces, at times so terrible, are ever working out their Divine Creator's will and ministering to human wants. Study them and they will interest you; examine their products and they will repay you. You will then recognize the truth of the words which our greatest dramatist puts into the mouth of his banished duke, when he declares that there are

Tongues in trees, books in the running brooks,
Sermons in stones, and good in everything.

Camel's hair is imported from Persia chiefly through the Russian ports, and is mostly used in the manufacture of pencils for drawing and painting. Camel's hair is longer than sheep's wool, and often as fine as silk. There are three kinds of colors, black, red, and gray, the darkest of which is considered the most valuable. It is said that the hair on a camel weighs about 10 lbs. In Bokhara the camel is watched while the fine hair on the belly is growing. This is cut off so carefully that not a fibre is lost, and when sufficient has been collected it is spun into a yarn unequalled for softness, and then dyed all manners of bright colors, and used chiefly for shawls. The Arabs and Persians make of camel's hair, of a less valuable kind, stuffs for carpets, tents, and wearing apparel, and cloth is made of it in Persia.

Several important public works have been projected for Alsace and Lorraine, the execution of which is to be shortly commenced. The principal of these are the canalization of the Moselle, which, according to the estimates, will cost 8,000,000 thalers (30,000,000 francs), and the excavation of a canal uniting Strasburg with the Rhine. Some of the intended improvements have been repeatedly promised by the French Government.

APPLICATION OF AMMONIACAL GAS AS A MOTIVE POWER.

By EMILE LAMM.

Ammonia, at the temperature of our atmosphere, is a permanent gas of well-known pungent odor. It is formed by the union of three volumes of hydrogen to one of nitrogen, condensed into two volumes. Its density is 596; air being 1,000. The density of the liquid, compared with water, is 76, or about one-fourth lighter than that liquid. Its vapor, at 60 deg. Fahrenheit, gives a pressure of 100 lbs. to the sq. in., while water, to give an equivalent pressure, must be heated to 325 deg. Fahrenheit. The volume of ammoniacal gas under the above-named pressure is 983 times greater than the space occupied by its liquid, while steam, under identical pressure, occupies a space only 303 times greater than water.

The above figures are taken from a work published in Paris by the editors of the "Annals of Civil Engineering," and have been substantiated in a lecture delivered by Mr. Poullet, before the French Academy of Sciences, on the apparatus of Carré for making ice by means of liquefied ammonia.

The latent heat of ammoniacal gas is 860, that of steam being 990. Ammonia is a powerful alkali. It rivals potassa and soda, and can neutralize the most powerful acids. Its action upon most of the metals is null; still, strange enough, it acts slowly upon one of the metals of the second class—*i.e.*, copper. Upon metallic iron, which is a metal of the third class, its action is absolutely null; but readily dissolves carbonated oxide (iron rust). Ammoniacal gas is absorbed by water with avidity—one volume of water at 70 deg. Fahrenheit, absorbing 500 volumes of the gas. The water becomes specifically lighter, while its volume is being augmented about one-third. As the absorption of the gas goes on, the water becomes heated, and the latent heat of the gas reappears as sensible heat. It is in this property that water possesses of absorbing so large an amount of the gas, and of becoming heated while absorbing it, that the practicability of using ammoniacal gas as a motive power rests, for it must be well borne in mind that the only agency for producing motive power is heat.

In 1833 Mr. Faraday discovered that ammoniacal gas was the vapor of a liquid which boils at 40 deg. below zero Fahr. The vapor of this liquid exerts a pressure, in a close vessel of 100 lbs. to the sq. in. at 60 deg. Fahr. The experiment is performed in the following way: A glass tube is procured, bent in the shape of the letter $_a\Lambda_b$ inverted, the end of the tube "a" is filled with a concentrated solution of aqua ammonia, from which the air is expelled by a gentle heat. The open end of the tube "b" is then sealed, after which the end "a" containing the solution is heated by means of an alcohol lamp, while the other end of the tube "b" is made to dip in a bowl of cool water. The gas expelled from the aqua ammonia, gradually accumulates on the top of the liquid, and when it comes to exert a pressure of 100 lbs. to the sq. in., the water in the bowl being at 60 deg. Fahr., it rapidly condenses, in the cool end "b" of the tube, into a highly volatile, clear, colorless liquid. After the experiment is concluded and the fire removed, and as the now nearly pure water, from which the gas has been expelled, gradually cools at the end "a" of the tube, the liquid ammonia boils in "b" and is rapidly reabsorbed in "a," leaving after a short time no trace of the experiment.

If the end "a" of the tube be made to cool rapidly by being turned around and placed in the bowl, the liquid ammonia in the bend "b" of the tube outside begins to boil violently, and the tube, by the rapid evaporation of the gas, is soon covered with ice from condensation of the moisture of the atmosphere around it, while the water, which now re-absorbs the gas in "a" becomes as much raised in temperature as "b" falls. By keeping well in mind the simple instrument which served Mr. Faraday's purpose for liquefying ammoniacal gas, the process now in use for the purpose of liquefying the gas for running street cars will easily be understood. Let the reader imagine that each end of the bent tube is enlarged, one end "a" being a large boiler, or retort, containing a concentrated solution of aqua ammonia, the other end "b" a large receiver, or condenser. If heat

is now applied to the boiler containing aqua ammonia the gas will be expelled from the solution if water at a temperature of 60 or 70 deg. Fahr. be thrown upon the condenser; the gas, after the pressure on top of the solution has attained 100 to 110 lbs. to the sq. in., will be forced, by the tension of its own particles, into a liquid, in the condenser. This larger operation resembles in every particular that of the glass tube. But when the operation is concluded in the practical still, communication is cut off by means of a faucet between the boiler and condenser, and the result is a large quantity of liquid ammoniacal gas, ready to be used at any subsequent time for the purpose of running street cars or anything else as required.

Now that I have given a short history of ammonia, and how it is converted into a liquid (this liquid being always ready to fly into gas or vapor when it is at a temperature of above 40 deg. below zero), let us suppose that a car is to be run from a station and back, a distance, say, of 10 miles. A vessel resembling in shape, say, a soda fountain, is filled with 15 gallons of liquid ammoniacal gas, which will be ample for the trip. The liquid is taken from the still by means of connections similar to those of water pipes; the fountain is permanently fixed on the car and connected to a small locomotive engine in the same way as a steam boiler.

Now, the whole invention consists in immersing the fountain filled with the liquefied gas on the car, in a tank containing some of the water which was left in the boiler "a" of the still. This water, or weak solution, is put around the fountain at any temperature desired—warm enough in winter to counterbalance the effects of the atmosphere; and it is easy to perceive that the boiling of the liquid in the fountain is in no way dependent on the heat of the air, but solely on the temperature of the water surrounding it.

I have yet to explain how the problem of working ammoniacal gas instead of steam was solved.

To comprehend fully the relation of heat to matter, some degree of mental application is necessary, for the first impressions created by our senses are liable to be erroneous. The insurmountable difficulty, hitherto, in the way of using liquefied gases as a motive power, has been the impossibility of supplying, without a recourse to artificial means, the heat necessary to convert their liquids into vapor. The point at which such a liquid may boil below the common temperature, making but little difference practically between the heat necessary to evaporate into steam a given amount of water, which boils at 212 deg. Fahr., and one that boils at 40 deg. minus, such as ammonia; the real and only difference, comparatively, being that of radiation in favor of the liquid which boils at 40 deg. minus, this radiation in summer being 120 deg., while the radiation against the evaporation of water would be 132 deg. Fahr. And even the above differences are more apparent than real, for they would only exist at the start, or when artificial heat would begin to be applied; for it is well known that our atmosphere transmits heat extremely slow. For example, we have but to observe the fact, how slowly a piece of ice melts when exposed to the air; this is owing to the great amount of heat absorbed during the process of liquefaction, and which mere radiation from the heat of our atmosphere is unable, even on the hottest day of summer, rapidly to supply. How much more heat, then, is required to convert a liquid into a vapor, need not be dwelt upon; and hence the absolute necessity of finding, even with liquids of very low boiling point, a means of heating other than the atmosphere in order to supply the heat necessary to their practical application for the production of power in lieu of steam; for if it was necessary to heat ammonia on a street car by means of a furnace, ammonia, then, would offer but little advantage over steam.

But ammoniacal gas possesses the remarkable property, from its affinity for water, of being able at any time after its condensation into a liquid, to re-produce at a distance from the furnace and still where it was condensed a force equal to the heat which was necessary for its condensation. This re-production is owing to the fact that the latent heat of the gas appears anew as sensible heat in the water of re-absortion, and is re-transferred to the liquefied gas.

In a trip of seven miles made by a street car driven by ammonia, the engine used on the car was equal to 2-horse power

and the ammonia expended during the trip amounted to $1\frac{16}{100}$ cubic ft. The latent heat of ammoniacal gas being 860, the whole heat expended during the trip would have been sufficient to raise 84 galls. of water from the temperature 83 Fahr. to the boiling point of 212 deg. If for supplying this heat it was necessary to rely upon the heat absorbed from our atmosphere, even on the hottest day of summer, I am positive that a car loaded with passengers could not run more than 300 yards without being obliged to stop, and wait at least 15 or 20 minutes in order to acquire sufficient heat from the atmosphere again to run an equal distance. In overcoming this difficulty, lays the gist of the whole invention. The exhaust pipe leads into an outside shell or water tank, in which is immersed the reservoir containing the liquefied gas. This ammoniacal gas escaping from the exhaust pipe, after having acted upon the piston of the engine, as soon as it comes in contact with the water in the tank, is instantly reabsorbed, giving out at the same time the heat which was rendered latent by its evaporation in the reservoir; and, since both the latent heat of a vapor and the sensible heat which it gives back, when condensed into a liquid again, are equal in quantity, there is really no heat lost in the apparatus while the engine is working, except the mechanical equivalent of the power produced; but a continual retransfer of sensible heat goes on to supply the heat which is rendered latent by evaporation.

This retransfer of heat is not instantaneous, and to overcome the delay in the communication of heat between the continually cooling liquefied gas and the water becoming as quickly warm on the outside of the reservoir, it was necessary to construct a boiler of numerous tubes, so as to increase the heating surface. To obtain the dynamical effect of a gas or vapor, all of the latent heat which may be extracted from it must be added to it as sensible heat. For example, if a volume of air be taken at the existing temperature, and compressed into one-half of the space it occupied originally, it will become hotter, and the degrees of heat indicated by the thermometer above the common temperature shall be the equivalent of the force of compression. Now, if this same volume of air, compressed into one-half its original bulk, be allowed to cool until it is in equilibrium with the surrounding objects, it will have lost much of its tension, and the original tension or force of the air, existing at the moment immediately following compression, can only be given back to it by heating artificially above the common temperature to the same degree of heat it possessed immediately after compression. The force which a given quantity of liquefied ammonia (contained in a reservoir) exerts upon the piston of an engine in developing 1-horse power, for an hour, at the temperature of 60 deg. Fahr., provided it be kept up, is equal to the heat necessary to distil the same quantity of ammoniacal gas from the solution of aqua ammonia under a pressure of 100 lbs. to the sq. in., at a temperature of 212 deg. in the boiler and 60 deg. Fahr. in the liquefier.

It can be laid down as an invariable principle that the same cause (circumstances remaining the same) produces the same result. But what are the circumstances of ammonia compared with steam? Both steam and ammonia are governed by a law (the law of Mariotte), which is essentially the same for all gases, viz., that all gases or vapors expand equally by the the same addition of heat.

The mechanical equivalent of heat expended in working the engine by ammoniacal gas, $\frac{1}{7}$ of the total heat, according to the best physicist, is fully made up by the extra heat of chemical combination becoming also sensible at the instant of the reabsorption of the gas in the water surrounding the tubes. The register of the pressure gauge at the moment of starting and during the trip, shows conclusively that the extra heat compensates all losses. The mean pressure during a trip remains essentially the same, if we take into account the time necessary for the transmission or equalization of heat between the reservoir containing the liquid gas and the reabsorbing water in which it is immersed.

On the trip mentioned above, the gauge registered at the start 120 lbs., and was the same at the end of the trip,—at no time indicating a variation of more than 10 lbs. to the sq. in.; and this has since been confirmed by over 300 trips.

If the reader refers to what has already been stated concerning latent and sensible heat, he will remember it is proved in substance, that the sensible heat which is

abstracted when the particles of a liquid go off in the form of vapor, and which enters into that vapor as latent, would again be returned to the liquid as sensible if the vapor could be recondensed in the liquid itself. In nature there are many gases which can be liquefied, and when they are compressed into liquids, at the ordinary temperature of the atmosphere, these liquids have then a tendency to resume the gaseous form, but are restrained by a pressure which equals in some of them 1,000 lbs. to the sq. in. These extremely volatile liquids boil at a temperature so low that, in such an atmosphere, a human being would quickly be frozen to death. If there are substances in nature with such enormous pressure at ordinary temperature, why are they not used as motive power, when, it naturally springs to the mind, the atmosphere would supply the fire? This is a delusion; the atmosphere could not keep them boiling for 5 minutes. Let us inquire into the reason. If we wish to operate with a liquid that boils at 100 deg. Fahr. below zero, our atmosphere would then be equal in summer time to a fire of 170 deg. It is only necessary to consider that it requires 1,800 deg. above the boiling point of water to produce steam with sufficient rapidity for the working of an engine, to see the utter impossibility of producing the same effect with a fire only 170 deg. above the boiling point of a liquid which obeys the same law as water. Furthermore, it should be stated that heat is imparted by a warmer body in contact with a colder one, in a space of time which is in the inverse ratio of the square of their intensity.

The above remarks show that the heat which the atmosphere can impart is always trifling in any given time when compared to that of an artificial fire, and this deficiency is owing really more to its slow transmitting power than to the difference in its actual intensity for the purpose required. For, if our atmosphere possessed a transmitting power even equal to that of water, its low intensity would then be made up by its increased capacity for transmitting heat. This might seem to be at variance with what I have just said above; but a more intimate knowledge of the physical properties of air and all gases in general, would make it perfectly clear to the reader. Air and all gases are the most imperfect conductors of heat we know of. If air could transmit heat as rapidly as water, it would only require 375 deg. instead of 1,800 deg. of heat under the steam-boiler to produce an equal effect; but as heat travels 60 times faster in water than in air, the intensity of the heat passing through the air must be 60 times greater to produce the same effect in the same time.

All truly scientific men contend, at present, that there is but little advantage in developing a force with a liquid that boils below the boiling point of water, for, say they, in their beautiful, concise language, "the sum total of latent and sensible heat of a liquid is a constant quantity at all temperatures it may be subjected to."

Now, the above being an absolute truth, there exists a liquid which can carry away from the furnace that produced it all of the heat imparted to it, and can then reproduce this same heat and its equivalent force without loss. This liquid is ammonia.

As has been shown already, the ammonia is driven off by heat from the aqua ammonia at the station. If the fountain, that contains the liquid ammonia, was to be put in one side of the car, and the water that surrounds it in the opposite side, their arrangement with the engine still subsisting, *i. e.*, that the pressure-pipe should come from the fountain, and the exhaust-pipe dip into the tank, the liquid ammonia would soon be too cold to give any pressure, and the water in the tank too warm to absorb any more gas; so that the result would be, on the one hand, the stoppage of the engine on the road from the liquid, that furnished the vapor, ceasing to boil; on the other hand, the water of re-absorption would become so hot that in order to maintain its power of absorption water would have to be carried on the car to throw upon and cool the re-absorbing vessel.

Now, we neither stop on the road, nor carry extra water to cool the re-absorbing vessel, nor use a furnace on the car to heat the liquid ammonia, but simply put the vessel having a tendency to become too cold, in the one which inversely is becoming too warm; this will equalize the temperature, and the car moves to the end of the trip.

A further advantage which ammonia possesses over steam, is the fact that its vapor, not being condensed at the usual temperature of our atmosphere, does not, like steam, at a low temperature, suffer condensation either in the cylinder of the engine, or when used at a distance from the boiler. The last remark leads me to speak of the cheapness of ammonia as a motive power, especially where only 1 or 2-horse power is required—such as on street cars. Its cheapness, when compared with steam, is owing to the fact that one steam-engine, if it could be made to propel 100 street cars with ease, would be much cheaper than 100 steam-engines, each requiring a separate fire and an engineer, besides the regular conductor of the car ; but the case is far different with ammonia, as a single engineer at the station can superintend the supplying of 200 cars with liquefied ammonia in sufficient quantity to run any distance within the limits of a large city, by means of a single fire under the stationary boiler from which the ammoniacal gas is liquefied. Further, liquefied ammonia can be compared, if I may be permitted the expression, to a bottled-up power, which can remain in a reservoir for months or even years, and be transported anywhere in any desirable quantity ; and then, at once, without any further preparation, can be used for any purpose desired ; and by the simple turning of a faucet can be made to act as powerfully as when first liquefied.

Practically, a large central depot could be cheaply erected with apparatus of capacity to liquefy a quantity of ammoniacal gas sufficient to propel all the street cars of a large city or other machinery. In thus indicating, in a general manner, the various applications of ammonia as a motive power, I must not forget to point out some other advantages which render it commendable :

First.—Its perfect safety—for the reason that its power is exerted at a very low temperature ; for it is a fact known beyond dispute, that the main agency which causes those frequent and deplorable explosions of steam boilers, is the high heat they require for the production of an effective force.

Second.—The fact that it preserves iron indefinitely, while water, as is well known, will destroy that metal rapidly. In view of these advantages it is difficult to say where the application of ammonia as a motive power will stop.

REPORT OF A COMMITTEE OF ENGINEERS UPON THE PERFORMANCE OF DR. LAMM'S GAS ENGINE.

NEW ORLEANS, LA., *June* 1, 1871.

DEAR SIR,—At your request we made, on the 23d ult., an examination of your ammoniacal gas engine, attached to a car of the City Railroad Company of this city, and we inquired also closely into your gas generating apparatus located at the depot of that Company on Canal street.

Your invention cannot be better described than in the language of your patent No. 105,581, dated July 19, 1870: "The first part of my invention relates to an addition made upon the steam engine, of water chambers inclosing the piston rod and valve stem, so as to render it capable of being worked by ammoniacal gas instead of steam without any loss whatever of the gas, which is returned to the common tank, where the exhaust is re-absorbed by a weak solution of aqua ammonia.

"The second part of my invention relates to the application of liquefied ammoniacal gas contained in a considerable number of iron tubes, as the liquid from which, instead of water, the motive power of the engine is derived.

"The third part relates to a weak solution of aqua ammonia, contained in a tank, in which the iron tubes mentioned above are immersed, and in which also the exhaust pipe of the engine is made to dip near the bottom. The gas exhausted while the engine is working is re-absorbed by this weak solution of aqua ammonia until the solution becomes saturated. The gradual re-absorption of the gas by the weak solution causes the latent heat of the gas to re-appear, the consequence being the re-transfer, by means of the several aforesaid metallic tubes (or surfaces) of the heat thus given out in the weak solution, to the liquefied gas. This re-transfer maintains a constant temperature within the tubes, the result of which is to keep an undiminished pressure above the surfaces of the liquefied gas, notwithstanding the expenditure of the gas in working the engine.

"It can then be easily perceived that the boiler of this novel motive power is

composed of two parts, viz.: First, a tank or shell; second, the tubular reservoir therein contained. There is no communication between those two parts, except through the engine.

"The tubes contain the liquid from which the motive power is obtained. The tank contains a solution which re-absorbs, as it comes through the exhaust pipe of the engine, the gas volatilized within the tubes. The ammoniacal solution surrounding the tubes becomes, by a remarkable phenomenon, as soon as the machine is set in motion, the furnace which maintains, by an easily regulated heat, the motive power at its maximum of tension.

"The fourth part relates to the general application of the invention, the most important of which, at the present time, appears to be the propelling of street cars, for which purpose it will certainly prove very economical, though I am satisfied that it is equally applicable, as a motive power, for all purposes whatever, and especially to the driving of machinery requiring only an intermittent action.

"By means of this invention any number of cars can be propelled, without fire thereon, for any reasonable distance, for liquefied ammoniacal gas gives a pressure, at the mean temperature of our atmosphere, of 100 lbs. to the sq. in., and can be readily and economically liquefied under pressure by a process now well known in the arts. For example, the cars can be propelled at the expense of one single fire, heating, at the depot, a large feeding boiler containing a concentrated solution of aqua ammonia.

"The process of liquefying the ammoniacal gas is rendered continuous by a fresh concentrated solution constantly pumped back into the boiler to replace the weak solution which is drawn off from its bottom. The process for a continuous supply of liquefied ammoniacal gas being well known, is here mentioned only for clearness' sake.

"The tubes in the inner reservoir are filled with liquefied ammoniacal gas, and the outer tank is two-thirds filled with a weak solution of aqua ammonia. The engine is now in condition to communicate motion, by pulley or any other gearing, to any machinery or vehicle, by simply opening the valve, and it works along as if propelled by steam, until the liquefied ammoniacal gas in the reservoir becomes exhausted.

"Now, as each car, has partly expended the gas contained in the reservoir, said gas having been during the trip absorbed by the weak solution of aqua ammonia, this now saturated solution is pumped back, at the depot, into the feeding-boiler for redistillation. The reservoir is then charged anew with liquefied gas, the tank resupplied with a weak ammoniacal solution, at a proper temperature, drawn from the feeding-boiler; the car is then ready for the trip. Thus, the expense of propelling an unlimited number of cars is that of the fuel and labor necessary to heat the feeding-boiler at the central depot, and the annual loss of ammoniacal gas, which does not exceed 25 per cent. of the quantity required for each car.

"A further proof of the economy of working liquefied ammoniacal gas, instead of steam, is derived from this fact, that 1 gallon of liquefied ammoniacal gas, under a pressure of 6½ atmospheres at 50 deg. Fahrenheit, expands into 983 volumes of gas; while water, under the same pressure, at 320 deg. Fahrenheit, only gives a volume of 295 of steam to one of water; also, the quantity of coal necessary to evaporate 3 gallons of water will produce 4 gallons of liquefied ammoniacal gas."

The following remarks relative to Ammonia are derived from various authentic sources.

Ammonia is composed of 3 parts of hydrogen and 1 of nitrogen—the product condenses to half its constituents. Under ordinary temperature and pressure, water dissolves or absorbs ⅓ of its weight, or about 670 times its volume.

The aqueous solution (aqua ammonia of shops) contains about 20 per cent. of its weight of ammonia.

Ammoniacal gas condenses into a colorless liquid at 38.5 deg. Fahrenheit under the pressure of the atmosphere, or 14.7 lbs. upon the sq. in. (which is the pressure under which all liquids boil), and it freezes to a transparent solid at 103 deg. Fahrenheit.

The solution ("aqua ammonia"), containing 670 volumes of the gas, has a specific gravity of .850; that of spirits of hartshorn is .960.

The solution absorbs 126 units of heat in its evaporization, while water absorbs 5 times as much, or 630 units.

The common "aqua ammonia" boils at 120 deg. Fahr., and it affords a pressure of 6 atmospheres at 232 deg. Fahr., while steam requires a heat of 320 deg. Fahr. to produce the same result.

Three lbs. of coal evaporates 3 gals. of water; while 3 lbs. of coal will produce 4 gals. of the liquid gas; 1 gal. of water, under $6\frac{1}{2}$ atmospheres at 320 deg. Fahr.= 295 volumes of steam; 1 gal. liquid gas, under $6\frac{1}{2}$ atmospheres at 50 deg. Fahr.= 983 volumes of gas.

The latent heat of water is 990 deg., and that of ammoniacal gas is 837 deg.

The boiling point of water is 212 deg., and of the liquefied gas 38.5 deg. below zero.

The boiling point of the ammoniacal solution, of 20 deg. Beaumé, is 140 deg.

The specific gravity of the gas is 0.59, air being unit; and of the liquefied gas 776, water being unit.

Water, thrown on a refrigerating worm or condenser, and of 70 deg. Fahr. at the start, can take up 20 deg. of heat and condense the gas still easily.

It will take about 40 gals. of water, at 70 deg., to liquefy 1 gal. ammoniacal gas.

The total loss of ammonia per annum should be taken at about 25 per cent.

Boxes of solution of ammonia, imported, contain 10 gals., *i. e.*, $\frac{2}{3}$ water and $\frac{1}{3}$ liquefied gas.

The apparatus on the car worked perfectly well, stopping and starting with great facility, and without a jerk, and seemed to be under the perfect control of the driver—a carpenter by trade, who had been handling it only a few days. The total distance per trip travelled over, with about 15 or 20 persons in the car, was 3 miles, the time taken being about 20 min. —it was evident, however, that we could have traveled faster if required. By taking the mean of several trips, we ascertained, by the glass gauge, that we had consumed or *solutionized* 1.44 gals. per mile of the liquefied gas, contained in the inner or tubular vessel. The weak solution which had been put in the tank or outer vessel, at 15 deg. Beaumé, was found to weigh 23 deg. Beaumé when drawn out after returning to the depot; thus showing that it had been enriched 8 deg. by the absorption of the gas from the inner vessel.

We are informed by Dr. Lamm that it requires 5 gals. of the solution at 25 deg. Beaumé—which can be delivered here, he says, at 40 cents per gal.—to make 1 gal. of the liquefied gas; the latter would therefore cost $2 per gal.

We then determined the time required at the depot to liquefy the gas, and its approximate cost, by the machinery which he now uses, and which is considered still quite imperfect. We found that $73\frac{1}{2}$ lbs. of bituminous coal liquefied, in 38 min., 18 gals. of gas from the solution of *aqua ammonia* at 23 deg. Beaumé. The well water used was at a temperature of 70 deg., and when taken from the condenser it showed 75 deg. The pressure of steam in the boiler during the distillation was 120 lbs. to the sq. in.; $37\frac{1}{2}$ lbs. of coal consumed is at the rate of 116 lbs. per hour; and as 8 lbs. are equivalent to 1 horse-power, it follows that $14\frac{1}{2}$ horse-power were used to obtain the 18 gals. of liquefied gas, or about $1\frac{1}{4}$ gal. per horse-power. The pressure gauge, meanwhile, showed $7\frac{1}{2}$ atmospheres, or $110\frac{1}{4}$ lbs. to the sq. in. The water used for the distillation would be $\frac{40 \text{ gals.} \times 38 \text{ m.}}{18 \text{ gallons.}} = 85$ gals., nearly, which multiplied by the 5 deg. added to its temperature, would give 425 deg. as the latent heat taken from the gas for every gallon of liquefied gas made.

We find that when coal is at $5.00 per ton, the cost of distilling aqua ammonia, at 23 deg. Beaumé, into 18 gals. of liquefied gas, with $7\frac{1}{2}$ atmospheres, or $110\frac{1}{4}$ lbs. on the sq. in., and the temperature at 80 deg., is as follows:

Coal, $73\frac{1}{2}$ lbs., or .03675 tons, at $5 = .	$0.18375
One engineer, at $5 per day, and 1 fireman, at $2 per day = $7 × .05277 days = ...	0.36939
Original cost of machinery, say $5,000; of which 20 per cent. per annum, or $1,000 ÷ 365 = say $3 per day × .05277 = ...	0.15831
Cost of liquefying 18 gals. of ammonia gas...	0.71145

Hence 1 gal. of liquefied gas will cost..$0.039525

It is evident that this result, which has been obtained under the most adverse circumstances, such as the newness, roughness, and incomplete condition of the machinery employed, will be greatly reduced when machinery better adapted

to the object in view shall have been adopted and applied on a larger scale, say for 25 or more cars. Moreover, ammoniacal gas, as a motive power, is in its infancy, requiring time and continued use, like steam, to develop its great advantages; hence we feel no hesitation in saying that your invention is a success, and that it will ere long replace the use of mule power on all city railroads, and wherever steam cannot well be used. It has the advantage, also, of dispensing with the use of fire, and of having at all times its motive power ready for instant use.

We now submit the following estimate, based on our observations as already given, for running 25 cars nearly 95 miles, each, per day, this being about the longest distance travelled over at present by any one car.

In the preceding experiment, made on a small scale, 2 men, at $7 per day, obtained 341 gals. of liquefied ammonia, while they could have made 5 times that amount on a larger scale; hence twice the force could liquefy 10 times the amount, or 3,410 gals. per day, at a cost of $14. And we assume that if the distillation was performed by direct heat instead of steam, the fuel would be economized one-third; that is, 1392.6 lbs. of coal per day, less one-third, will give 928.4 lbs., which multiplied by 10 will be equal to 9.284 lbs., or 4.64 tons at $5. But the cost of the improved machinery would be increased from $5,000 to $15,000, the interest upon which may be taken at 8 per cent.; the wear and tear, repairs, oil, etc., at 12 per cent.; the interest on the capital ($864) invested in ammonia, at 8 per cent.; and the loss of ammonia per annum at 25 per cent. on said capital of $864; hence we find the following cost for making 3,410 gals. of liquefied ammonia for 25 cars running 2,368 miles per day, in all:

Interest on $15,000, at 20 per cent. per day	$8 22
Interest on $864, at 8 per cent.	19
Loss on ammonia, $864, at 25 per cent.	60
Coal, 4.64 tons, at $5	23 20
Labor	14 00
Total cost per day for 25 cars	$46 21
One car per day will then cost	$1 85
Hence 1 mile will cost	0.019

or nearly 2 cents per mile.*

We have not availed ourselves of the economy claimed to be due to the use of ammoniacal gas in preference to steam, on account of its volume at 100 lbs. pressure being 3 times greater than that of steam under the like pressure. We have confined ourselves to the fact, that all liquids are simply the agents to transmit the heat or power of the coal consumed in the furnace, in the same manner as a belt or spur wheel does relative to animal power; hence we say that a pound of liquefied ammonia is equal to a pound of water, when both are subjected to the same force or heat; for, if the former, by volume, be 983, and expands 309 times, while that of steam be 303, and expands 1,397 times, the force of each will be nearly as 42 to 30, which is nearly as that of their densities—*i. e.*, 100 to 76. Therefore we would give the preference for running street cars to ammonia, which requires only the temperature of the atmosphere, even if it cost more than steam, as we would prefer to a spur wheel, a belt which makes but little noise, although it might slip occasionally.

The following objections, we are informed, are urged against the use of ammoniacal gas as a motive power:

1*st.* The danger of explosion.

2*d.* The deterioration of the iron by corrosion and brittleness due to the action of ammonia.

3*d.* The heat in the (outer) tank of weak solution of ammonia becoming too great as the distance travelled over increases.

These objections are, we consider, groundless. In the first place, only a pressure of from 3 to 10 atmospheres (45

* The following facts relate to one-horse cars on street railroads in New Orleans.

These roads are generally from 5 to 6 miles long, which is the length of the trip for one horse or mule, and he repeats this trip from 3 to 4 times per day; hence he travels from 15 to 20 miles per day, and the cars run from 80 to 110 miles each, according to length of road.

From 5 to 6 horses or mules—including sick and convalescents—are allowed per car, according to length and condition of the road. Horses generally cost from $150 to $200 per head, and mules from $200 to $250. The mortality is about 5 per cent. per annum of the whole number used, and the sick and convalescents are about 10 per cent. The feed and attendance of the stock cost about 55 cents per day per head, depending on the market price of grain and fodder.

The total expenses per car, including repairs of tracks and cars, feed, pay-rolls, office-rent, insurance and contingent expenses, on a road say of 6 miles in length, and on which about 50 cars are kept running, amount to from $9.50 to $10.50 per day, of which about 50 per cent. belong exclusively to those items resulting directly or indirectly from the use of horses or mules.

As to the preference to be given to either kind of animal, it is still a mooted question; but it is probable that on long roads, where *speed* is required, horses have the advantage; their first cost is, moreover, cheaper. The objections to them are, that they require more care than mules, and do not last, under ordinary circumstances, quite as long.

to 150 lbs.) to the sq. in. will be ever used in liquefying ammonical gas as a motive power for car purposes; whereas, in the manufacture of *ice* a pressure of 16 atmospheres (240 lbs.) is frequently required, yet no accidents have happened in those manufactories which have been for several years in operation in America and Europe. Moreover, the ammoniacal gas is generated by the difference of temperature between 40 deg. below zero and about 80 deg. above (or that of the atmosphere); whereas, steam is generated by the heat of a furnace, at about 2,000 deg. Besides, the sensible heat of the steam is 340 deg. at the same pressure as the ammonia. These temperatures are irregular, being dependent entirely on the intelligence and faithfulness of the engineer and fireman. And, as it has been determined by reliable experiments that iron heated to 1,200 deg. above the ordinary temperature loses $\frac{2}{3}$ of its strength, the danger from steam will be apparent to all.

Relative to the second objection raised, that iron is corroded and rendered brittle by contact with ammonia, the result of observation shows, on the contrary, that it has the reverse effect, preserving it from rust; while, singular as it may appear, it rapidly corrodes copper.

With regard to the third objection, that the heat in the solution tank or condenser will become too great as the distance travelled over increases, thereby tending to produce an explosion. This danger need not be apprehended, for the heat in the condenser being dependent on the evaporation of the liquefied gas in the tubular boiler, cannot, under any circumstances, be of greater intensity than that which produced it; but even if possible, it would simply produce a back pressure equal to that of the tubular boiler pressure, and the engine must come to a rest.

We cannot conclude this report without expressing our acknowledgment for the patience you have shown and the courtesy you have extended to us during our investigation. We sincerely hope that fortune may follow in the wake of an invention destined to place your name high on the scroll of Fame, alongside of those which have illustrated the present century.

We remain yours most truly,

G. T. Beauregard,
President N. O. and C. Railroad Co.,
I. L. Crawcour,
John Roy,
Engineer and Architect.

To Dr. Emile Lamm,
President Ammoniacal Propelling Co. of America.

STREET LOCOMOTION.

From "The Engineer."

A sudden terror has seized the public mind in reference to street tramways. Last year nothing was so popular. This year the car of Juggernaut would scarcely be more terrible to the inhabitants of Oxford street than the prospect of a tramway car trundling along from the Marble Arch to Holborn. New modes of locomotion always inspire alarm. Railways were once the dread of agriculturists, and the horror of territorial proprietors. That era having passed away, there next arose a cry of alarm when railway engineers proposed to invade London. Not even Printing-house square was safe, and the "Times" began to thunder against the projectors of intramural lines. Parliament took the matter resolutely in hand, and proceeded to sift the schemes so as to reduce the apprehended inconvenience to a minimum. Public feeling gradually quieted down, until roused once more in reference to the carrying of a railway to the Mansion-house. Railways are still pushing and feeling their way into the heart of London, and the public are readily availing themselves of the vast convenience thus afforded. Another mode of locomotion now presents itself—a sort of handmaid to the railway system, combining the easy traction of the rail with the primitive haulage of the horse. The authorities of the Board of Trade have looked with favor on this hybrid production, and tramways have become immensely popular since the disappearance of George Francis Train and the introduction of an improved rail. The eccen-

tric gentleman from New York did his best to make tramways a general abhorrence, and helped to delay their introduction by a few years. Something like the old feeling of antagonism has been revived of late, in consequence of numerous bold attempts to introduce tramways into the more crowded and fashionable parts of the metropolis. We are not saying that the opposition is altogether unreasonable, but we believe it emanates very largely from two portions of the community, the one being an important and the other an estimable class—namely, shopkeepers who have what are called "carriage customers," and the other class consisting of ladies who ride in the aforesaid carriages. The pleasurable excitement of "shopping" is threatened. The shopkeeper trembles for his profit, and the fair sex apprehend a serious interference with their indispensable amusement. Of course honorable members—particularly the metropolitan — cannot withstand this twofold influence. All the shopkeepers in Oxford street, except three infatuated beings, have petitioned against tramways. All the ladies in Mayfair and Belgravia would do the same if they had the opportunity. It is all very well for members of Parliament to write to the daily papers and say that the tires are wrenched off their carriage wheels, and that their horses get their legs sprained. The real fact is that every lady who rides in a carriage detests the tramway. In the nature of things it must be so. Not only does a tramway interfere with that perpetual zigzagging from one side of the street to the other, which is indispensable to the perfect pursuit of shopping, but there is something essentially and obtrusively democratic in a tramway. When a dainty pair of greys have to be pulled up at the behest of some insensate cabman, or stolid 'bus driver, the incident may be attributed to mere individual eccentricity or obtuseness. Under such circumstances Jeames himself may laugh compassionately, and her ladyship smile at the odd perverseness of the offender. But the tramway is an institution. It runs straight down the street, and when the driver puts his whistle to his mouth everybody must get out of the way. It is too palpable that the car clears all before it. If the driver wished to get out of the way he couldn't, and the vehicle sweeps on its course among the throng of equipages, as inexorable as fate. The whole affair is democratic, or what is worse, it is democracy possessing an exclusive power. It is a Yankee notion, and the West End shakes its head at the thing. It may do for Brixton or Whitechapel, but it may not be allowed in Oxford street, or even dreamed of in that paradise of peeresses—Regent street.

But what says Demos to all this? Demos is a creature who rides in "'buses," or occasionally sports a cab. He dives into underground railways, and patronizes penny boats. Demos, when a boy, rode in hackney coaches, those ponderous vehicles which disappeared so mysteriously about 30 years ago. We fancy there is a specimen at South Kensington, but cannot speak with certainty. When a youth Demos rode in a two-wheeled vehicle, the driver whereof was stuck on outside over the off-wheel in a manner marvellous to behold. It was a patent machine for breaking necks, and was gradually superseded by vehicles designed for the protection of the public. Finally there came the "growler," a sort of box on wheels, safe to break nobody's neck; and the "Hansom," a contrivance which has proved eminently popular and useful. In the midst of these mutations the London omnibus, like the penny steamboat, has adhered to its original type. Demos hates it. It is too conservative for him. Repeatedly has he sought to reform it, but he has never succeeded. It persecutes him unmercifully. It pitches him out backward when he tries to get in, plunges him into his neighbor's lap when he attempts to sit down, smashes his hat when he goes to the upper end, causes torture to his toes when he sits at the door, deafens him with its roar as long as he is inside, and finally flings him in the mud when he tries to get out. As for riding outside, many an acrobatic feat at a music-hall is less perilous, and a ride on the knife-board is like dancing on the edge of a precipice. We believe that the conductors of these singular vehicles are quite conscious of their defects, for only in that way can we account for the general civility which characterizes this class, in which respect they are decidedly superior to railway porters, and perfect angels when compared to those ferocious creatures who go about armed with nip-

pers, and with the dreadful words "ticket collector" embroidered on their collars. But to return to the omnibus. We believe it was invented in the latter part of the seventeenth century. It ought never to have lived in its present state to the latter part of the nineteenth century, taking the London omnibus as a specimen. Still it does live, to the torture of horse-flesh and the torment of Demos.

But Demos has of late enjoyed a ride in the tramway car. As he glided along, without jolt or rattle, and breathed the air of a spacious compartment, he relaxed his clenched teeth, stretched his weary legs, half wondered where he was, and at length exclaimed, "This is the ticket." The Board of Trade befriended him, and tramways were sanctioned by the score. But Aristos suddenly awoke, and there was thunder in St. Stephen's. A member of the Carlton, whose residence commands the junction of Edgeware road and the line to Oxford street, has led an onslaught against the ways of Outram, and Parliament has followed in his wake. The provisional orders of the Board of Trade are being upset, bills are being rejected, and tramways are told to keep their distance. There is great rejoicing among the directors, shareholders, officials, and servants of the London General Omnibus Company, Limited. Demos hangs his head and thinks dolefully of the inevitable "'bus." But there is hope even yet. In saying this, we don't mean merely that there is Mr. A. J. B. Beresford Hope, of Arklow House—Pandora's box has something in store for Demos. The other day the unfortunate Demos entered an ordinary omnibus, and to his infinite surprise it neither roared nor rattled. It seemed floating on a cloud. The silence was almost oppressive. He could positively hear himself speak, and the clatter of the horses' hoofs broke on his ear with an almost painful distinctness. While wondering at this strange phenomenon, he was startled out of his self-possession by an astounding crash, and a sensation as if an earthquake had suddenly laid hold of the omnibus. He was ready to rush past the conductor, when the mystery was explained. He had been riding on Val de Travers' asphalt, and had suddenly reverted to granite blocks. "All is not lost," thought Demos. Let asphalt be laid in the streets of London—such asphalt as more than one company can now produce, and possibly the need for tramways will either disappear or become very much modified. But the road omnibuses must be improved. The dead pull at starting must be superseded by the contrivance which gives the car the benefit of a start without a jerk. There must be a brake, so that the vehicle can be pulled up on the asphalt in something less than the eighth of a mile. The vehicle must be enlarged, and the passengers made comfortable. If the omnibus companies will agitate for asphalt, and will improve their vehicles, Demos will be less anxious for tramways. It is possible that tramways will ultimately triumph over all opposition; but the demand for them will be very much lessened if the public are allowed the benefit of asphalt in conjunction with proper vehicles. The street locomotion of London needs reform, and in some shape or other it must come.

M. E. Becquerel has shown that the electric spark may be diversely and beautifully colored by being made to pass through saline solutions. If an electrical spark from an inductive apparatus be made to pass into the extremity of a platinum wire suspended over the surface of the solution of a salt, this spark will acquire special coloration according to the chemical composition of the solution traversed. The saline solutions are best concentrated, and the platinum wire positive. The experiment is readily performed in a glass tube. Salts of strontia will color the spark red; chloride of sodium, yellow; chloride of copper, bluish green, etc. The light from these sparks, analyzed by the spectroscope, furnishes a method for the determination of the nature of the salts contained in the solution.

The Elevated Railway in this city is again in operation. A light dummy is used, which hauls two car-loads of passengers.

Flocks of ostriches are being raised in South Australia for the sake of the feathers, the demand for which in Europe exceeds the supply.

NEW SYSTEM OF MINE VENTILATION.*

From "The Engineering and Mining Journal,"

The best methods of mine ventilation rest on the same principles as those of domestic ventilation. Whether we use the furnace, now almost and most fortunately out of use, or the *fan*, which is taking its place, to the great advantage of good ventilation, the action is the same, and a parallel case is not difficult to draw.

The great evils of our domestic ventilation are the prevailing evils of our mine ventilation also ; but in addition to the vitiated air of respiration, condensation, combustion, etc., we have to contend with the spontaneous exhalation of carburetted hydrogen from the coal, in most of our deep mines ; and in this constant and abundant generation of one of the most dangerous of explosive gases lies the chief difficulty and danger of our mining economy.

Still in the cure of the first great evil of our present system of ventilation, we find the remedy even for this ; because here again the great laws of nature become available, or the provisions of nature suggest a remedy. Like heated air, carburetted hydrogen only needs the means of escape. Its tendency to fly upward is about equal to that of air heated to 500 deg. of temperature; consequently, if permitted to escape from the mines freely, this dangerous and now troublesome gas would not only become harmless, but might be made useful. Instead of a bad master, it might become a good servant.

But this consummation is impossible as long as our mines are ventilated on the principle of too many of our houses ; and just here a parallel case may be drawn. We may compare a common chamber, or breast, or the face of a gangway, with the rooms of our dwellings, having only the flue of the stove or fire-place, perhaps but 4 or 5 ft. from the floor, for the escape both of the vitiated air of respiration and the products of combustion. Of course, above the point where the flue exists, the space is a receptacle for heated air, which, as long as it retains a certain degree of heat or rarefaction, will occupy this area with all the impurities of respiration and combustion common to such dwelling rooms, where there is no provision made for their exit by means of escape flues in the upper portion of the walls.

In a mining chamber, particularly when the coal bed is a "pitching" one (having a large angle of dip), there must always be a considerable space beyond the influence of the air currents ; and this dead or stagnant place in all such chambers is always the highest portion. In this portion, corresponding to the upper part of a dwelling-room, the miner pursues his daily avocation ; and here of necessity, in most of the chambers of a pitching coal-bed, he is compelled to work in foul air, and too frequently in an atmosphere of inflammable gas, simply because it is impossible, in most cases to make the air-currents pass along the face of the chamber in order to provide pure air to the miner and to carry off the gases that exhale from the coal.

To those familiar with our methods of ventilation, this proposition is plain, because we now carry the air currents from chamber to chamber, by means of cross-headings through the pillows which separate the chambers. Such cross-headings are always considerably in the rear of the "working face" of the chamber. Even if commenced close to the face, the face is constantly being advanced further and further from the cross-heading, through which the air-current passes, leaving the space in advance in a stagnant condition.

If the air is carried up on one side of a chamber and down the other, this same difficulty exists, unless there is a sufficient amount of "gob" to keep the middle of the chamber closed up near to the working face. This is scarcely ever the case; and the only other way in which the air-currents can be made to pass close to the face, is when the "rear" method is made use of. But this method is seldom available, and still more rarely desirable.

If we take the case of a gangway, or the main entry, with its parallel air-way, we find the same difficulty to exist, because here, as in the chamber, or the dwelling, there must always be a space in which stagnation exists, where the air-current cannot be made to pass, and where the

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* A paper read, May 18, 1871, before the American Institute of Mining Engineers, at Wilkesbarre, Pa., by S. Harries Daddow, of St. Clair, Pa.

gas will accumulate in any mine generating carburetted hydrogen.

The space in advance of the heading is always in this stagnant condition, unless air is supplied to the face by the small hand fan, which is often employed under such circumstances, unless the gases are abundant.

Thus our present system of ventilation is powerless to reach the vital point. It cannot pass the air-currents where pure air is most wanted. It is always behind, too low, or too far off from the miner; and is consequently compelled to work in a vitiated atmosphere, or worse, in an atmosphere of fiery elements. But here, as too often in our dwellings, we ignore a law of nature, and complain of the dangers to which we are compelled to submit, as if those dangers were also the result of inexorable, unchangeable laws.

If our analogy has been fairly made, natural ventilation will appear to be the same in the house as in the mine; but it appears to be more difficult to provide for the free escape of the gases of the mine than of the heated air of the dwelling. We have not, however, prepared this paper merely to present difficulties with which we are, unfortunately, too familiar; but confidently offer a method which we believe will prove a remedy as available as it is in every way desirable.

ARTESIAN OR FLUE VENTILATION.

This innovation, which we will now try to present as briefly and concisely as possible, the writer claims as his invention, and presents it as such without hesitation, feeling confident of its practical utility both in regard to safety and economy.

The invention consists, first of a drilling machine, to be propelled by steam, compressed air, or water, which is light, strong, portable, and easily operated. This drilling machine is designed to make flues from each chamber to the return air course, or, in other words, *to drill holes in the place of cross-headings* for the escape of the gases and foul air from the chamber in front of the miner, just as the flues in the upper part of a room allow the heated air to escape naturally.

The author then exhibited a photograph representing the drilling machine in its smallest and lightest form ; but a double machine is designed to bore long flues, say from 300 to 500 ft.

The operation or cost of boring these flues from gangway to gangway, or from airway to airway, either on the dip of the coal-bed, or parallel to its strike (that is, at right angles to or parallel with the gangways), is a small matter compared with the cost of the frequent cross-headings now necessary, but dispensed with when the flues are substituted. Cross-heading is slow and costly; but the act of boring these flues through the coal is rapid and comparatively cheap. From 10 to 20 ft. per hour can be made by the machine drill with two men, while a yard per day is about the average advance made in the cross-heading. It may be argued that a flue 6 in. in diameter would be insufficient for the purpose designed ; but when we calculate the amount of air or gas, or both combined, that will pass through such a flue, we find even 4 in. ample for the ventilation of a single chamber.

These flues always lead from the chamber to the return air-course. They empty in the return; consequently, the suction of the fan is constantly exerted on the area of the flue, inducing rarefaction and a rapid current in the flue, and from the chamber. This flue is in the solid coal always in advance of the chamber. In fact, the chamber follows the flue; so that the escape of the gas and foul air is directly in front of the miner and away from him; while the natural lightness or ascensional tendency of the gas is thus made available, not only to make its own exit, but to carry away in its train other evils.

Every chamber is thus ventilated through an independent flue. The gas and vitiated air are drawn off directly from the locality in which they are generated. If the flue ascends, the gas would rush up of its own lightness, but when the flues are nearly horizontal, the suction or draw of the fan has the same effect on the foul air and gases. The fan, or some other mechanical means of drawing a current of air through the mines, is now always used, whether the beds are horizontal or inclining, consequently this power is always exerted to induce a current in the flues, just as the current is drawn through the heading at present. Of course, if the gas and foul air are drawn out of a chamber, the pure air will fill its place, because "nature abhors a

vacuum," and an abundance of pure air is provided in all the main gangways and in all the chambers, which are constantly open for its free entrance, without doors, or batteries or other diversions.

The flues thus convert the carburetted hydrogen from a dangerous gas to a useful element, while the miner may work fearlessly in his chamber, not only well rid of a lurking enemy, but in an abundance of pure air and *light*, because the naked, blazing lamp may be used where the dim light of the safety-lamp is frequently now all that the miner dare risk.

In addition to the difficulty, or, in fact, impossibility, of providing pure air to each miner, in the face of his chamber, by the cross-heading method, on account of the tendency of the gas to remain inside or above the headings, another serious evil exists in the mode of carrying the air-currents in large volumes, from chamber to chamber, through the mine. The gathering impurities go with the current, and pass from one miner to the other. Every opportunity is given to produce an explosive element, and nothing but an excess of pure air can prevent it in a gaseous mine. Consequently, 30,000 cubic ft. of pure air is necessary to ventilate, by the present method, where 5,000 cubic ft. is ample by the flue method, because it requires 10 times more pure air to render the gas innoxious than to supply the necessary air for the use of the workmen.

The simple use of the flue, always in advance of the work, thus provides perfect ventilation, and immunity from the dangers of explosive gases.

It may now be a question of practicability and relative economy between the present and the proposed methods.

PRACTICABILITY.

The question of practicability lies simply in our ability to drill long holes in any direction through the coal; but we know, by actual experience, that a horizontal hole 300 ft. long can be drilled in *hard rock* by machinery less available than the drill now proposed. We know that coal can be drilled in any direction, or at any angle, at the rate of from 10 to 20 ft. per hour; and should the top or bottom rock be met by any undulation of the bed, the diamond drill employed will pass through it. The flues may be drilled from the upper levels downward to the lower levels, or from the lower levels upward to the upper levels; but, while the flue-method applies as well to the right angle blast or chambers, up the dip of the bed, we prefer, for many reasons, the *barrel-chambers*, which are driven at right angles to the dip, or parallel with the gangways. In such chambers the flues are bored horizontally, and with the course of the gangway or the "strike" of the bed.

RELATIVE ECONOMY.

If we ignore entirely the many and great advantages secured in pure air and immunity from danger by the use of the artesian flues, and only compute the relative cost of boring flues and of driving cross-headings, we think no one would complain of unfairness.

We will take the simple case of a gangway, with its parallel air-way, and calculate that a cross-heading is driven between the two, a distance of 21 ft., at a cost of $5 per yard, or $35 ; while a single flue, 6 in. in diameter, could be bored in 2 hours, costing less than $5, if steam or compressed air is used, and less than $1 if water from the pumps is used as the motive power. In some of our gangways, where the gases are generated rapidly, a cross-heading is required every 20 ft.; but from 30 to 50 ft. may be more nearly the average distance from one cross-heading to another, either in gangway or chamber. We may calculate that every 1,000 yards of gangway or chamber will require from 100 to 150 yards of heading. By the flue method, the length of the flue is equal to the length of the chamber; consequently, in ventilating the chambers by this method, the length of the flue will be from 7 to 10 times the length of the cross-heading ; while in the gangways the length of flue would be equal to the length of cross-heading, and no more. But 10 yards of flue can be drilled at much less cost than 1 yard of cross-heading can be driven. On the whole, we think the cost of the flues would only be about half the cost of cross-heading as usually practised ; but we are willing to allow that the cost in this respect may be equal, including the cost of outfit, general maintenance, power, and operation. Still, should there be no actual economy in the relative cost of driving headings or of boring flues, we accomplish a desirable purpose with the one which cannot be

obtained by the other. We secure life, health, and safety, for which we now pay a *premium;* because we cannot expect a man to assume these risks for mere laborer's pay. Nor can we expect as much labor from a miner working in constant danger, if not in actual dread, as from one who feels secure and works without apprehension. Moreover, there is less professional skill required in the mere act of digging coal than experience, hardihood, and fearlessness in meeting and managing the dangers of our imperfect systems of mining and ventilation.

In the artesian flue system there is also a saving and convenience in dispensing with all doors, batteries, hand-fans, safety lamps, and fire bosses. The system is plain, simple, cheap, and applicable to all good systems of mining.

FLUE PIPE EXTENSIONS.

When an air-way, incline, shute, or heading, is driven at points where the artesian flue cannot be bored, a system of sheet-iron pipes, made and put together on the principle of large stove-pipes, is used. Those pipes are fitted into an artesian drill-hole, extending from the gangway into the parallel air-way, and from thence the pipes are carried in any direction or angle, in one of the upper corners, or any place on top of such headings, etc., as are now supplied with air by the hand-fan. The suck of the fan on the mouth of the flue, and consequently on the flue-pipe, will draw the air up, or into such heading, by exhausting the gas and vitiated air from its face.

It is evident that an artesian flue cannot be bored so as to ventilate the main gangways, close up to the face. It is true that these holes may be bored quite close to the face, and much more frequently than cross-headings are now used, and would, therefore, carry the air much closer to the face than would otherwise be done; but, in order to secure a constant supply of pure air, the pipe-flues can be extended up to the face of the gangway, and the opposite end inserted in one of the artesian holes leading to the return air-way.

In connection with this system of artesian flue ventilation, and the drilling machinery which necessarily accompanies it, I have also constructed a suction fan on new principles, in order to get increased suction or drag in the return air-courses, and consequently in the flues, and for the further purpose of reducing the dimensions, or rather the diameter of the artesian flues as much as possible.

In order to create greater suction-power, I found it necessary to provide some means of preventing depression, and at the same time increasing the diameter of the side openings, which, under ordinary rules, would defeat the ends sought. But this desirable improvement I at length secured by using three fans in combination. The ordinary fan, as now used, is introduced, with a double cone around the shaft, the smaller ends on the line of the shaft or axis, and the bases joined together at the bases of the wings, thus diverting the air from the horizontal to the vertical line with the least possible friction or tendency to counter-action. But, in addition to this, I place a hub or extension at each side, and in these I place two fans, one on each side, with oblique vanes, on the principle of the anemometer, whose whole object and action is to suck the air in at either side. Of course, I can increase the size of the side openings in this fan to double the size possible on the old plan, because depression is simply impossible; and I thus obtain a plain, simple fan that will do double the work that can be accomplished by any other suction fan.

The system of ventilation herein proposed, however, is entirely independent of this new style of fan, which is not a necessary adjunct, but only a means of reducing the flues from 6 in. to 4 in. diameter. The common fan or the furnace can be used in connection with the flues just as they are used at present. No change in our modes of mining is actually necessary, though the band system is recommended as the most available, under all circumstances, both as to economy of mining and as to ventilation.

In this method the air invariably enters through the main gangways, passing up into the chambers, only as fast or in such volumes as can be carried off by the respective flues. Exhausted or worked-out chambers are closed, and the inside air-course, communicating from the lower to the upper level, is provided with a regulator to pass off the surplus air, and insure a sufficient quantity to each chamber.

M. JANSENN'S BALLOON COMPASS.

From "Engineering."

The annexed particulars of an aeronautical compass, designed by the distinguished French astronomer, M. Jansenn, for determining the course and speed of balloons, are given in "Comptes Rendus" for February last, but have not, we believe, been noticed before by any English papers.

The balloon compass consists of a cylindrical metal case, $3\frac{1}{2}$ to $4\frac{1}{2}$ in. (10 to 12 centimetres) in diameter, and the same in height, fitted with a glass bottom, and open at the top. Two small arms on branches rise from the upper end of the case, and support between them a little metallic disc at a height of 10 to 12 in. (28 to 30 centimetres) above the glass bottom. This metal disc serves as an eye-piece, for which purpose it has a small hole a few millimetres in diameter, drilled in the line of axis of the cylinder. To this hole the eye is applied during observation.

Upon the glass bottom are engraved a number of concentric graduated circles, whose radii are so calculated that they may be visible through the eye-piece under angles of 1, 2, 3, and 10 deg.

The largest of these circles carries diametrical lines joining the points 0 and 180 deg., 90 and 270 deg., 45 and 225 deg., 135 and 315 deg. on its circumference. This is called the great circle.

The instrument is fitted with a suspensory apparatus upon Cardan's principle, so as to insure the verticality of the axis of the cylinder during observation. A compass needle is fitted to the glass bottom, a little eccentrically, so as to leave the vision unimpeded in the line of axis. This is also provided with a small graduated circle, of which the needle's pivot is the centre, and which is so divided that the cord of 180 deg. may be parallel to the line 0—180 deg. of the great circle.

This compass will show both the course and rate of speed of a balloon.

The instrument is hung clear of the car by means of hooks inserted in the balloon's equator. It is adjusted by bringing the needle over the meridian line of the compass circle, *i. e.*, over chord of 180 deg. Looking down at the earth's surface through the eye-piece, we wait until some suitable object or portion of an object appears in line of axis. We then count the seconds which elapse before some object clears the great circle (the eye being close to the eye-hole all the while), and note the division of the circle at which it makes its transit. The meridian line of the compass, and consequently the needle when the instrument is in adjustment, being parallel to the diametrical line 0—180 deg. of the great circle, a line drawn from point of transit to centre of great circle will make with line 0—180 deg. an angle equal to the bearing of the balloon's course from magnetic meridian. This angle must be corrected for declination to give true course. When the balloon is disturbed by rapid rotary whirls, as sometimes happens, allowance must be made for the effects. The axis of the compass, in place of pursuing a course parallel to the line followed by the centre of the balloon, describes a cycloidal curve, and the course indicated is a tangent to the curve at the point of transit. But, it must be remembered, these tangential lines form equal angles, but of opposite signs, with the true course in each pair of points separated by a half rotation of the balloon. A mean of the apparent angles thus obtained should therefore be taken.

To measure the speed, we have to note the time apparently occupied by a point on the earth's surface in traversing a radius of the great circle. In reality it is the time occupied by the balloon in describing a conic projection of such radius upon the earth's surface. This time bears the same proportion to the altitude of the balloon above the earth's surface as the radius of the great circle bears to the height of the instrument. Now the radius of the great circle being calculated so as to be seen through the eye-piece under an angle of 10 deg., it follows that this proportion is as the tangent of 10 deg. to radius, *i. e.*, as 0.176 to 1. If, therefore, the time observed be 18.4 sec., and the altitude of the balloon 2,200 metres, the speed will equal $2{,}200 \times \frac{0.176}{18.4}$, or 21 metres per sec., which is 76 kilometres (about 47 English miles per hour).

This, it may be observed, was the speed of the "Volta" during M. Jansenn's famous trip from Paris en route to join the "Eclipse" expedition. It will thus be seen, M. Jansenn writes, that the calculations required are of a very simple character. The necessity of performing them in the balloon may be obviated by having a small table prepared, so as to show the results on inspection.

The course and rate of speed can thus be obtained by a single observation, the only additional data required being the altitude of the balloon, which is taken by the barometer. Here, too, much time and trouble may be spared by using a pocket table with the corrections suited to the meteorological elements of the day of observation. In place of the barometer, small grenades on the concussion principle may be employed. One of these dropped from the balloon will ignite on striking the ground, and the number of seconds betwixt the flash and the arrival of the report will give a sufficiently clear approximation to the altitude.

The compass may be employed to ascertain the balloon's course in another way. The branches before referred to are furnished with small sight vanes. With the aid of the latter we may determine the azimuth of distant objects. By thus observing a distant object over which the balloon has passed, we can ascertain the magnetic bearing of the balloon's course. M. Jansenn adds that perfect repose is not essential to the employment of the instrument. Moments of exceptional disturbance must be avoided, but under ordinary circumstances it will be sufficient to have the car well balanced, the aeronauts keeping in their places and guarding against any movements calculated to disturb the "trim" of the machine. He found no difficulty in using an ordinary telescope in the "Volta" whenever required.

M. Jansenn promises further information upon the subject of instruments for the determination of the course and speed of balloons at night or in foggy weather. His observations have not, we believe, as yet appeared.

THE HANNIBAL BRIDGE.

From "The Railroad Gazette."

This combined railroad and highway bridge over the Mississippi river, at Hannibal, Mo., has just been completed, the seventh structure that spans the great river, below Dubuque. The work has been completed under the administration of the "Hannibal Bridge Company," formed by the consolidation of two companies—the "Pike County Bridge Company," incorporated in Illinois in March, 1867, and organized June 4, 1869, with Alexander Starne, President and Ozias M. Hatch, Secretary and Treasurer; and the "Hannibal Bridge Company"—incorporated in Missouri, May 24, 1869. In December, 1869, the consolidation was effected under the present title of the company; Mr. John T. K. Hayward, of Hannibal, was elected President and Ozias M. Hatch, of Springfield, Ill., Secretary. The present organization of the company is: Alexander M. White, President, Isaac M. Knox, Secretary and Treasurer; Warren Colburn, Consulting Engineer; Col. E. D. Mason, Chief Engineer, with E. L. Corthell and Eliot Clarke as assistants.

On the 27th of June, 1870, Col. Mason, with his corps, commenced the preliminary surveys, making minute examinations of the river bed and the underlying strata at various possible crossing places. By means of sounding rods, he bored to a depth at some points of 110 ft. below low-water mark. The direction and velocity of the current was carefully noted by the use of floats, and the line of the bridge was located at right angles to it. A base-line of 1.620 ft. was accurately measured, and its extremities indicated by raised monuments. From this line as a base all the positions for the piers were located by triangulation, and afterwards tested by actual measurement with a steel wire, proving their accuracy.

On the 29th of July, 1870, a contract for both substructure and superstructure of the bridge proper, between and including the abutments on each side of the river, was entered into with the Detroit Bridge and Iron Works. The plans for the substructure had been previously prepared by Col. Ed. D. Mason, the Chie

Engineer. The Bridge Company adopted the plans of superstructure as designed by Willard S. Pope, Engineer of the Detroit Bridge and Iron Works. The agreed price for the whole was $185,000. By the terms of the contract the work was to be completed ready for use within one year. The time was very short—much less than that before given for any similar work, but the contractors have met the requirement.

This bridge belongs to the general class of "low bridges," placed but a short distance above the high-water mark and furnished with a draw span over the channel to permit the passage of steamers and river craft generally. The comparative advantage of high and low bridges over navigable streams is a question of money only. The high bridge, offering practically no obstruction to river traffic at any stage of the water, and requiring no attention on the part of its keepers in distinction from the constant service required at a draw, presents, in this respect, points of superiority over the low bridge. But the increased height of the piers, and the length of approaches necessary to attain the elevation, adding very largely to the cost of the structure, led in this case to the adoption of the low bridge and draw as the most economical structure. Confirmations of this opinion are furnished by the bridges at Quincy, Burlington and Kansas City, as well as by the plan adopted for the bridge to be built at St. Joseph. At St. Charles, St. Louis and Leavenworth high bridges have been favored and adopted for reasons other than those of economy.

The bridge under consideration is nearly identical in form with those at Burlington and Quincy, differing only in some of the mechanical details. One of the more important distinctive features is the form of the struts or posts used. These are composed of two parallel channel or I beams secured a short distance apart by diagonal bracing of wrought iron straps, forming an open work strut, the interior of which is accessible to the brush of the painter, whose attention is frequently needed to prevent rust—the destroying enemy of iron structures. The free ventilation afforded prevents the condensation of moisture in the interior and consequent rust, a salient feature of the tube-like "Phœnix column." In weight for the same strength there is little difference, while the facility of construction is slightly in favor of the new form. The form of the chord link differs from that used at Quincy in being formed of bars and eyes, instead of the experimental form built there of elongated links drawn out from a flattened ring. The upper chord shows an important modification. Instead of being of continuous size throughout, the ends of each section are considerably enlarged and the abutting faces planed exactly perpendicular to the axes of the beams, thus adding much to their stiffness and allowing the omission of the short diagonal lateral braces. The increased size of the chord at the joints permits the passage of the tie road to an interior fastening, instead of being secured to a *lug* on the outside.

The foundations, upon which depends the permanency of the work, in all cases—excepting that of the west abutment, which is built up from the rock—are supported upon pile bases. The piles in piers 2 and 3 were driven to the rock, and at the other piers they were driven until a sufficient resistance was obtained. Upon the piles, cut off at a level with the bottom, was placed a grillage of heavy timber, forming the foundation for a floating caisson. This caisson was sunk to its position as the masonry part of the pier was added to its weight, the sides being kept above water until the mass was fairly settled upon the pile heads. This method, when admissible, furnishes the most economical, as well as expeditious, means of placing the masonry upon foundations under water. To prevent scour, the spaces between the piles themselves, and the space between the bottom of the grillage and river bed, are filled with riprap, and a bank is formed, around the outside, of the same useful material. The serviceable nature of riprap in resisting scour is well known, and the engineer in charge of this work has been led by his experience to place great confidence in its ability to withstand the currents of the Mississippi.

At the west abutment the rock bed of the river was found but a short distance below the surface, and the masonry was placed directly upon it. The rock, a variety of blue soapstone, was excavated in steps, to receive the wing walls. This abutment contains 372 yards of masonry.

The following table shows the time occupied in the construction of each pier, and the depth of water at the several points at the time of the sinking of the respective piers.

Piers.	Work Commenced.	Completed.	Depth of Water.
			Ft.
Pier No. 1 (West abutment)	Oct. 10, 1870.	May 27, 1871.	0
" No. 2	Oct. 10, 1870.	Nov. 13, 1870.	18
" No. 3 (pivot pier)	....	May 27, 1871.	31
" No. 4	Dec. 13, 1870.	March 8, 1871.	22½
" No. 5	Jan. 8, 1871.	Feb. 4, 1871.	14
" No. 6	Dec. 6, 1870.	March 5, 1871.	10
" No. 7	Nov. 22, 1870.	Jan. 31, 1871.	10
" No. 8	March 27, 1871.	April 5, 1871.	12
" No. 9 (East abutment)	Feb. 15, 1871.	April 22, 1871.	5

Pier No. 2, being situated in the current of the river, required protection piles as a guard against drift. All piles were driven to the rock bed, thus demonstrating that piles could be used for the sub-foundations, by properly protecting them from scour, with riprap placed between and around them by divers. The average number of blows to the piles in the foundations was 112, from a hammer weighing 2,700 lbs., falling 25 ft. at the last blow. A floating caisson, formed of grillage of 12-in. sq. oak and elm timbers, well bolted together, and carrying planked sides to above the water line, was guided in its descent by cables, which were secured to a water deadener, and side anchors, until it was settled upon the heads of the cut piles, at a depth of 18 ft. below the water line of that date. The stonework consists of 496 cubic yards of masonry.

The piles of pier No. 3, the pivot pier, were driven to the rock, and, after dredging out the sand to a sufficient depth, were protected by riprapping. A sunken crib was used as a water deadener. Much trouble was experienced from sand banks forming over the heads of the cut piles, requiring the use of divers, dredges, and, finally, a water jet thrown from a steam fire-engine.

The dipping of the rock bed carried it beyond the reach of the piles for piers 4, 5, 6, 7, 8 and 9, and these piles were driven in the sand until a sufficient amount of resistance was obtained; the permanency of the sand being secured by that indispensable material, riprap.

At piers 8 and 9 the sand had to be dredged out to allow the wooden grillage to be placed at a sufficient depth below low-water mark—the condition of durability of the wood-work being that it must *always* be covered by water, in order to exclude the air. In this situation it is practically indestructible.

The draw rests are sunk on islands of riprap, and consist of strongly braced cribs presenting a sloping edge to the current. Their interior is filled with riprap to the top.

The bridge is approached from the west by a long curve, completing a right angle with the river and passing through a tunnel of 302 ft. in length, cut through what is called lithographic limestone. The excavation was made at the east heading with Burleigh drills and powder and nitro-glycerine blasts. At the west end, by hand-work alone, a heading of full width, and some 9 ft. in depth, was driven through the top of the heading, being on a line with the roof of the tunnel; the bottom was cut out afterwards. Its dimensions, after being lined throughout with brick, are 302 ft. long, 20 ft. high, and 18 ft. wide.

Both entrances are ornamented with handsome cut-stone faces.

The approach at the east bank of the river is over 1¾ miles of embankment, across the river bottom land, broken at proper intervals by paved culverts and roadways, and protected by revetment walls at points subject to wash.

The following analysis has been made of the two qualities of limestone from the Hannibal quarries used in the foundations.

The figures in this analysis give evidence of the comparative superiority of this limestone, as claimed by the engineer, in that it has comparatively small quantities of alumina a small capacity of ab-

sorption and consequent density, and very great specific gravity.

Constituent Parts.	Hannibal Brown Limestone, upper layer.	Hannibal White or Blue Limestone, lower layer.
Insoluble in acids	1.295	0.390
Iron	0.640	0.453
Alumina	0.550	0 852
Carbonate of Lime	80 805	93.365
" Magnesia	14.650	2.320
Alkalies	1.060	1.120
Water	1.000	0.500
Total	100.000	99.500
Specific gravity	2 563	2.585
Weight per cubic feet	159.73	161.00

As stone from the same quarry has already stood long and severe tests in some of the older buildings at Hannibal, there is no necessity for fine argument upon its chemical composition, and no reasonable doubt can be entertained of its being all that is required for the purpose.

In the foundations there were used 650,000 ft. (board measure) of square timber and plank, 709 piles, and 6,270 cubic yards of riprap. There are 4,519 cubic yards of masonry in the piers, distributed as follows, numbering the piers from the west bank: No. 1, 372; No. 2, 496; No. 3, 1,340; No. 4, 514; No. 5, 400; No. 6, 326; No. 7, 333; No. 8, 310; No. 9, 430.

In the superstructure are 1,000 tons of iron, and 280,000 ft., board measure, of timber and planks in flooring.

The cost of the bridge proper was $485,000, the tunnel on the west bank $36,000, the west approach $56,000, and the east approach $71,500—making the total cost of the structure $648,500.

SUPERSTRUCTURE.

The spans are arranged as follows: Beginning at the west bank of the river, one fixed span, 250 ft. long; one pivot draw-span, 362 ft. long, leaving, when opened, a passage way for steamboats 160 ft. clear width on each side of the draw pier; one fixed span, 250 ft. long; and four fixed spans 180 ft. long each. The measurements of length are taken in each case, from centre to centre of masonry, and then the total length of the bridge, from centre to centre of bridge-seats of abutments is 1,582 ft.

The superstructure is of the general style known as the quadrangular truss, with horizontal and parallel chords, vertical struts—except those at the ends, which are inclined over one panel—and inclined ties. In the fixed spans the upper chords and the joint pieces, etc., are of cast iron, and all the remaining parts are of wrought iron. The draw-span is of wrought iron throughout, except joint pieces and wheels, truck, etc., of the turn-table, the flooring placed at the bottom of the bridge, and is uniformly 18 ft. wide.

The general characteristics of the different lengths of spans are as follows:

	In draw-span 362 ft. long.	In one fixed span 250 ft. long.	In one fixed span 180 ft. long.
Depth of truss between centre of chords, at pivot pier	34 ft.		
Depth of truss between centre of chords, at ends	26 "	25 ft.	23 ft.
Width between centre of chords	20 "	19.6 ft.	19.6 ft.
Number and length of panels, 2 centre panels	11.2 ft.		
Number and length of panels, 26 ordinary panels	12.11 ft.	19 pan 13 ft.	13 pan 13.7 ft.
Weight of cast iron	65 tons.	50 tons.	25 tons.
Weight of wrought iron	235 "	125 tons.	63 tons.
Oak flooring	31 M.	22 M.	16 M.
Pine flooring	31 "	22 M.	16 M.

STRENGTH OF BRIDGE.

The main parts of the structure are so proportioned that a moving or live load of 2,500 lbs. per lineal ft. of bridge, in addition to the weight of the structure itself, and the flooring thereon (or the dead load), shall bring on no part a greater strain than $\frac{1}{5}$ of its ultimate capacity. This general rule was applied to those parts which receive their assumed load only when the whole or a considerable part of the span may be occupied by a train of the assumed maximum weight. Those parts, such as single-panel systems, which receive their full load each time an engine may cross the bridge, are utilized to the extent of

$\frac{1}{6}$ their ultimate capacity, while the bolts supporting the floor system can never receive a load exceeding $\frac{1}{5}$ their strength. The actual relation, therefore, between the calculated final strength of the structure and its assumed working duty is shown to be as follows, taking the 250-ft. span as an instance :

Dead weight of span	240	tons.
Live load of span	310	"
Total weight and load	550	"
Ultimate strength of bridge (factor of safety 5)	2750	"

The dead weight, of course, remains constant under all conditions ; therefore, of the gross strength ot the bridge 2,510 tons is applicable to the support of the live load, which is in the ratio of more than 8 to 1.

In other words, when the bridge is fully loaded with its assumed maximum of 2,500 lbs. per lineal ft., it will still be capable of sustaining before fracture the imposition of an additional load of 2,200 tons.

This large excess of strength is practically still further increased, from the fact that the assumed live load of 2,500 lbs. per lineal ft. can never be actually reached, even though the bridge were loaded from end to end with engines, and from the additional fact that the actual strength of the iron used is considerably in excess of that demanded by the specifications. This combination of circumstances and facts gives a reasonable assurance of abundant strength.

CONSTRUCTION.

The top chords of the fixed spans are of cast iron, octagonal in exterior section and circular within. In the 250 ft. spans these chord pieces are 14 in. in diameter between the opposite exterior faces. The thickness of metal varies with the varying strains.

They are cast in lengths of one panel, the joint occurring immediately over the head of the vertical posts to which each chord-piece is bolted. The ends are widened for the reception of the post-head, the main and counter tie-rods, and the upper lateral strut and ties, all of which assemble at that point. Thus while in the 250 ft. spans the chord-pieces are 14 in. wide throughout their interior length, they widen at their ends to 24 in. This increase of width at the joints increases largely the lateral stiffness of the bridge. Where the chord-pieces abut against each other, their faces are turned off in a lathe square and true to their axes, and they are connected with each other by a tenon and socket joint.

Immediately under the joint is placed the post or vertical strut, the seat for which, on the under side of the chord, is planed to a true bearing. The post-head is of cast iron, machine-finished to correspond with its seat. The posts themselves are of rolled channel or I beams, arranged in pairs, connected together by a system of wrought-iron riveted lattice-work. The two beams thus united form a hollow, open post, rectangular in section. They range from 10 in. to 24 in. wide, varying in depth with the depth of the constituent beams. The beams extend from the post-head to a point 6 in. below the centre of the main coupling-pin passing through their foot ; the pin-seat in the post being reinforced by a cast-iron plate or washer riveted to the web of the beams. The beams of which the posts are built vary in dimensions in accordance with their duty, from channel beams of 6 in. depth weighing 10 lbs. per ft., to I beams of 15 in. depth weighing $66\frac{2}{3}$ lbs. per ft.

It will be seen from this description that the posts are continuous and without transverse joint from end to end ; and, furthermore, that all faces or sides of the iron of which they are built are at all times open to inspection and accessible to the paint-brush. It is considered that this is a material improvement over the closed cylindrical wrought-iron posts that are often used in similar places. Such a construction generally involves the necessity of an independent cast-iron foot or base, thus placing a full transverse joint across the body of the post; and, furthermore, the inside of these posts can never be reached either for inspection or protection, after they are once in place.

The main and counter ties are placed in piers connected at the lower end with the bottom chords and posts by a pin, and at the upper end passing through the top chord immediately over the post-head and secured in their position by nut and screw. They run diagonally, reaching from the pin at the foot of one post to the head of the second post beyond, their vertical rise being the depth of the truss and their horizontal reach being the length of 2

panels. They are of rolled iron, square in section, their lower part being formed into a loop, which is drilled to fit the pin; and their upper end being shaped into a cylindrical form on which the screw is cut. The end forming the screw is enlarged so that the sectional area of metal at the bottom of the screw thread is in each case larger than the sectional area of any part of the body of the bar. The nuts are faced to a true and perfect bearing on their respective seats.

The lower chords are of square iron of the length of one panel, formed with a drilled loop at each end, through which the pins pass. They vary in size and number in each panel, according to the duty demanded by their position. In their manufacture the most scrupulous care was taken to have them all of exactly uniform length between centres of pin-bearings.

The upper lateral struts are of rolled channel beams 6 in. deep, weighing 10 lbs. per ft., placed in pairs, between the top chords at their joints over the post-heads. The lateral ties above and below are of round iron bars $1\frac{1}{4}$ in. in diameter.

The floor-beams consist of rolled I beams 15 in. deep, weighing 50 lbs. per ft. suspended in pairs from the pins at foot of posts. The bolts suspending the floor-beams and the coupling-pins are forged bodily from selected scrap, under heavy hammers, and afterwards machine-finished for their respective positions.

The above description of the parts of the fixed spans applies equally to the draw-span, except that in that span the chords are necessarily different, as is demanded by the varying nature of the strains, which change from compressive to tensile, or the reverse, as the draw is open or shut.

They are built of channel beams 12 in. deep, $33\frac{1}{3}$ lbs. per ft., placed in pairs, and connected together with plate iron, thus making generally a trough or hollow box of 3 sides, 24 in. wide, and about 12 in. deep. The joints, which are carefully broken, are spliced with appropriate cover-plates, and the whole thoroughly riveted together.

The top and bottom chords are substantially similar, varying in dimensions, etc., only with the varying duty. The turn-table on which the draw-span revolves consists of a rectangular hollow girder or drum, 18 in. wide, and $4\frac{1}{2}$ ft. deep, curved to a circle, with an exterior diameter of $37\frac{1}{2}$ ft. The sides of this drum are of plate iron, and the top and bottom are of cast iron, and are separated by 30 cast-iron stiffners, or diaphragms, carefully fitted to which, and to the top and bottom segments, the side plates are thoroughly riveted. This circular drum revolves upon 48 heavy cast-iron wheels or rollers, placed under it, and they in their turn rest upon a cast-iron track bolted to the masonry of the pier. These wheels are connected with each other and with the centre step by bands and radial axles. The wheels and the upper and lower track bearings are chilled to great hardness to resist wear. From the bottom of the revolving drum pass truss-rods, the upper ends of which bear upon a heavy central cast washer, at the bottom of which is the pivot-pin, of wrought iron, 8 in. in diameter. This pivot-pin turns upon a gun-metal bearing in the top of a central conical block of cast iron, which is fastened to the masonry.

The adjustment of the load between the exterior wheels and the central pivot is made by means of the truss-rods above mentioned.

The ends of the draw are secured in their position on the piers by means of a system of cams, so arranged with screw and connecting rods as, when being run down, to absolutely lift the ends of the bridge. This device is essential, as otherwise, when a train might be entering upon one end of the draw, one wing being thus loaded and the other wing being empty, the unloaded end would rise from its bearings, and thus serious and complex strains be induced upon parts of the structure.

But by absolutely and sufficiently lifting the ends of the bridge upon solid bearings this difficulty is entirely avoided, and the structure can thus be treated legitimately and correctly as a beam resting upon 3 points of support, and the complexity of the problem of strains be immensely simplified.

The bridge is turned and the machinery of the end cams operated by a double engine of about 20-horse power(nominal) placed on an iron platform laid for the purpose on beams supported by the main posts over the turn-table. This platform or floor is placed at a sufficient height

above the lower chords to allow the passage of trains beneath it.

QUALITY OF MATERIALS.

Samples of all the wrought-iron bars used in the bridge were tested to their ultimate capacity before acceptance.

The tensile strength ranged from 55,000 to 65,000 lbs. per sq. in. of sectional area, and the lowest limit of permanent set was about 2,500 lbs. per sq. in.

The stretch before final rupture was about 20 per cent. of the length of the original bar, and the diminution of area proportional therewith.

The cast iron was from a mixture of 75 per cent. of No. 1 Lake Superior charcoal pig, with 25 per cent of Scotch pig of the brand known as "Calder iron."

Test pieces were cast 2 in. deep, 1 in. wide, and 40 in. long. These were placed edgewise upon bearings 36 in. apart, and were called upon to sustain the transverse strain from a load of 2,800 lbs. placed at the centre.

All the test pieces showed higher capacity. The hollow chord pieces were drilled and accurately callipered for thickness.

After manufacture and before being placed in the bridge, each piece of bar iron was placed in the testing machine, and subjected to an actual tensile strain of 15,000 lbs. per sq. in. of sectional area, and while under such actual strain, received several sharp blows from a hammer. Any imperfection or weakness detected by this treatment condemned the bar. Of the many hundreds of bars thus treated, only 2 exhibited any sign of failure, and in both these instances the defect was in the original bar, and not in any part that had been worked at the shops. As soon as finished, and before leaving the works, every piece received 1 coat of paint, composed of oxide of iron and oil.

All the iron work was done at the shops of the Detroit Bridge and Iron Works, at Detroit, and having been fitted together there, each piece was marked, so that when brought to the place of final erection every part went to its place with perfect accuracy.

FLOORING.

Upon the iron floor-beams are laid pine stringers, placed longitudinally. Under each rail in the track are 2 pieces, 7x16 in., and in addition thereto are 4 parallel pieces, 6x14 in. All these are laid upon small oak bolsters, which rest upon the iron beam. On the top of the stringers are oak ties, 6x8 in., spaced about 20 in. apart, between centres, reaching entirely across the bridge. A double course of 2-in. oak flooring-plank forms the roadway, the track for engines and cars being of the pattern known as street rail, the top of which is flush with the top of the oak flooring. A substantial oak wheel-guard, and a strong neat hand-rail form the side protection.

PAINTING.

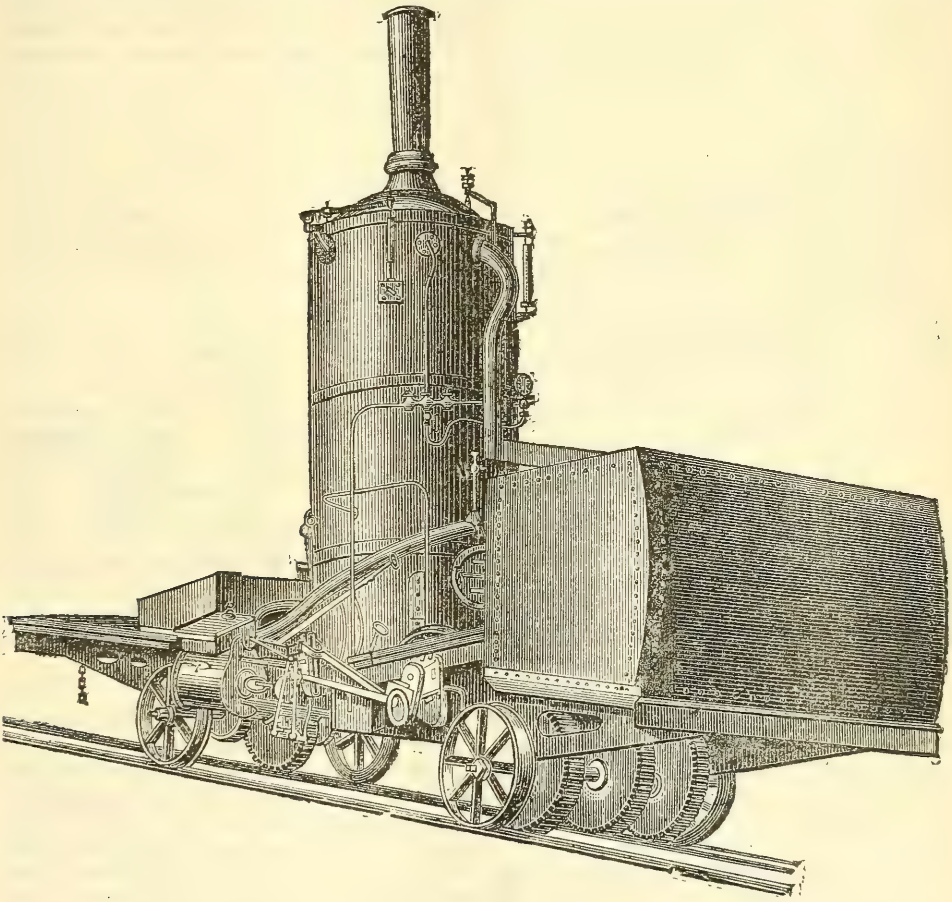
The entire superstructure received, after erection, 2 thorough coats of paint. For the main trusses the paint was of strictly pure white lead, tinted to a light drab, while the floor-beams, track-stringers, and hand-rail were covered with iron paint of a dark brown shade.

A LATE number of Poggendorff's "Annalen" contains an account of an experiment made by E. Budde, to ascertain whether a Leindenfrost's drop with water could be produced at a less temperature than 100 Cent. The experiment was made by letting a drop of water fall upon a hot plate covered by a partially exhausted receiver, and it was found that the drop assumed the spheroidal condition at a temperature of 85 Cent., confirming the doctrine that the force which supports the drop obeys the laws of the pressure of vapors. The star shape assumed by the drop, Berger has explained to be a phenomenon of vibration. If the drop is large it behaves like other vibrating bodies, and divides into aliquot parts, forming nodes or loops.

THE state of the Belgian iron trade continues favorable. Almost all descriptions of iron are in good demand, especially plates ; considerable quantities of these latter have been sent to Germany. A contract for 2,000 tons of rails for the North-West Austrian Railway has been divided between the Thy-le-Château, the Couillet, the Monceau, and the Sclessin Works.

THE RIGI RAILWAY.

The "Organfur die Forschritte Eisenbahnwesens" gives the following particulars of the railway that has been lately opened (23d May) on the Rigi. The line commences at Vitznan on the Lake of Lucerne, and terminates for the present at the baths of Mont Rigi, situated at 4,000 ft. above the level of the sea, but will be ultimately extended to the top of the mountain. This bold undertaking is chiefly due to Messrs. Naef, Zchoke, and Riggemback, who, previous to commencing the works, made a series of experiments at Olten for the purpose of testing the various systems of mountain engines, amongst which may be mentioned that of Mr. Fell, which is adopted on the Mont Cenis tunnel railway, the Welti engine,



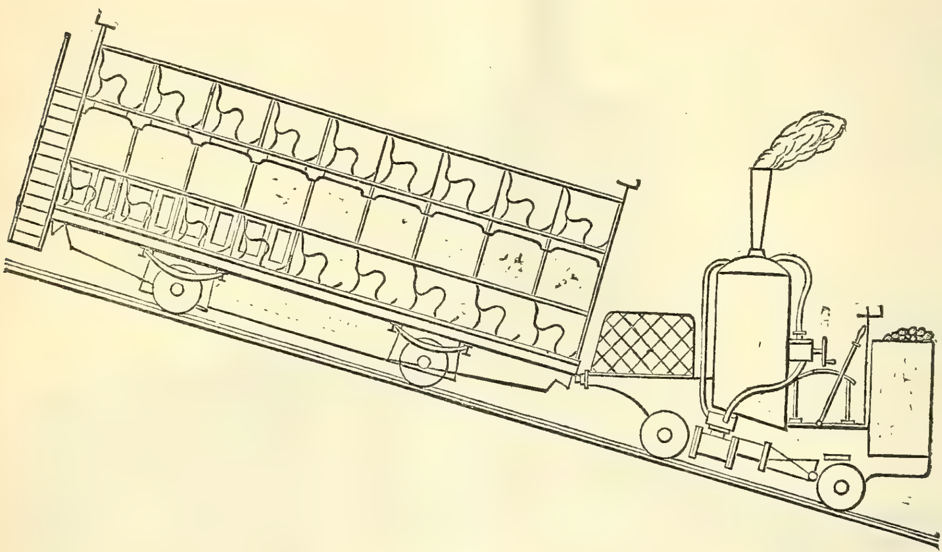
etc. The engine of Mr. Riggembach was found to be the best suited for the purpose, and was therefore adopted.

The line commences at a turn-table 12 metres in diameter, situated at a short distance from the lake, and, ascending with a gradient of $6\frac{1}{2}$ per cent., reaches the village of Vitznan. Here the gradient changes to 25 per cent., which is retained (with the exception of some short lengths of 22 per cent.) to the summit. The curves are numerous and are principally of 180 metres radius. At 1,000 ft. above the level of the sea the line passes through a tunnel in the rock $67\frac{1}{2}$ metres in length, and immediately crosses a ravine 30 metres in depth by a viaduct, consisting of 3 spans of $24\frac{1}{2}$ metres each.

The piers for supporting the girders are of iron work, strongly braced together and firmly fixed in foundations of granite ; these piers are 10.80 and 8.10 metres in height respectively. The girders are placed 2.10 metres apart, and the distance between the parapets 4.20 metres. To add to the difficulty of the undertaking, the viaduct is situated on a curve of 180 metres radius, and with a gradient of 25 per cent. On the viaduct the rails and rack are fixed to longitudinal sleepers.

About half way up the mountain, near the Freibergen station, the line is provided with a siding to allow the up and down trains to pass each other, and at the lower end of the line there are also sidings communicating with the engine sheds. There are 3 watering stations on the line, supplied by natural pressure obtained from the mountain springs.

Several deep cuttings through the rock, and high retaining walls in various places on the line, were found necessary to be made, and as, from the steepness of the locality where the line had to be made, it was found impossible to employ carts for the transport of earth, sledges were used. A sufficient quantity of stone,



fortunately, was near at hand for the construction of the various works in masonry, and had only to be hewed into shape and rolled into place. The workmen employed on this line were chiefly Italians.

With such steep gradients, and on such rough ground, which in places was almost inaccessible, it may be easily supposed that the setting out of the line was a task of no slight difficulty. On leaving the lake the railway takes a south-westerly direction towards the rocks of Vitznan, and on leaving the tunnel the course of the line is north-west, and on this part of the line the passengers will not fail to enjoy the magnificent panorama of the lake at their feet, with the Alps in the back-ground, with the valleys of Lucerne, Alpnach, Buochs, and Weggi.

The permanent way consists of light rails, of the form known as "vignoles," weighing only 33 lbs. per yard. The gauge is the ordinary 4 ft. $8\frac{1}{2}$ in., the rails being fished at the joints. The sleepers are of oak, 8 ft. in length, and placed 2 ft. 6 in. apart. The end of the sleepers are bolted to longitudinal timbers, thus forming a strong framework ; besides this every fourth sleeper is firmly fixed to the rock by masonry, so as to prevent any chances of the line slipping in a longitudinal direction. In the centre of the line between these rails is a rack, fixed to the sleepers by angle irons, weighing about 4 cwt. per yard.

The passenger trains consist of a 4-wheeled engine, and of a carriage with an upper story, capable of accommodating 80 persons. This carriage is pushed up by the engine, instead of being drawn, as on other railways, and in descending the mountain the engine is in front, so as to sustain the carriage, which, however, could descend entirely by itself, and is entirely under control of powerful brakes.

The speed on this line is certainly not great, occupying about 1¼ hours from the lake to reach the summit, a distance of about 5,500 metres (rather under 3½ English miles). The engine is of 120-horse power, and the steam is produced in a tubular boiler, which is vertical when on the steep gradient. The weight of the engine is 10 tons. A toothed wheel is fixed on the driving angles, and makes 1 revolution to 3 of the steam engine. This wheel works into the rack, which is placed in the centre of the line, and it is in this manner that adherence is obtained for overcoming the gradient. The engine is prevented from running off the rail by strong angle-irons, which are fixed to the under part, so as to prop it on each side of the rack. In descending, a powerful new brake is used.

The carriages are composed of 2 stories with 9 seats each, and are capable of accommodating 45 persons on the lower story, and 36 on the upper.

The cost of the line, including 3 engines and 3 carriages, was 350,000 thalers (£56,000).

On the Great Sun-spot of 1843.—One of the largest and most remarkable spots ever seen on the sun's disc appeared in June, 1843, and continued visible to the naked eye for 7 or 8 days. The diameter of this spot was, according to Schwabe, 74,000 miles; so that its area was many times greater than that of the earth's surface. Now, it has been observed during a number of sun-spot cycles that the larger spots are generally found at or near the epoch of the greatest numbers. The year 1843 was, however, a *minimum* epoch of the 11-year cycle. It would seem, therefore, that the formation of this extraordinary spot was an anomaly, and that its origin ought not to be looked for in the *general cause* of the spots of Schwabe's cycle. As having a possible bearing on the question under consideration, let us refer to a phenomenon observed at the same moment, on the 1st September, 1859, by Mr. Carrington, at Redhill, and Mr. Hodgson, at Highgate. "Mr. Carrington had directed his telescope to the sun, and was engaged in observing his spots, when suddenly 2 intensely luminous bodies burst into view on its surface. They moved side by side through a space of about 35,000 miles, first increasing in brightness, then fading away. In 5 min. they had vanished. . . . It is a remarkable circumstance that the observations at Kew show that on the very day, and at the very hour and minute of this unexpected and curious phenomenon, a moderate but marked magnetic disturbance took place, and a storm, or great disturbance of the magnetic element, occurred 4 hours after midnight, extending to the southern hemisphere." The opinion has been expressed by more than one astronomer that this phenomenon was produced by the fall of meteoric matter upon the sun's surface. Now the fact may be worthy of note that the comet of 1843, which had the least perihelion distance of any on record, actually grazed the solar atmosphere about 3 months before the appearance of the great sun-spot of the same year. The comet's last distance from the sun was about 65,000 miles. Had it approached but little nearer, the resistance of the atmosphere would probably have brought its entire mass to the solar surface. Even at its actual distance it must have produced considerable atmospheric disturbance. But the recent discovery that a number of comets are associated with meteoric matter, travelling in nearly the same orbits, suggests the inquiry whether an enormous meteorite following in the comet's train and having a somewhat less perihelion distance, may not have been precipitated upon the sun, thus producing the great disturbance observed so shortly after the comet's perihelion passage.

The Conservators of the Thames have framed a new set of by-laws for the better navigation of the river, and especially with a view to the prevention of collisions, for which they intend to obtain an order in council.

ON THE DURABILITY OF CAST AND WROUGHT IRON FOR ENGINEERING STRUCTURES.*

By G. J. CROSBIE DAWSON, ESQ., C. E.

From "The Artizan."

It is rather remarkable, I always think, that our early engineers rarely used iron in any of their structures, and it is only within the last few years that the valuable properties of the metal seemed to have been universally acknowledged by the whole profession as applicable to almost every kind of engineering work. There is no other substance of greater use to man, being so well adapted to form such a variety of things, tools of almost every description, machines of all kinds, steam engines, etc., and there is no other metal more abundant throughout the world than iron; it is found in almost every inorganic body, and where iron ore is found in plenty there generally are seams of coal adjacent. Iron has been used from the very earliest times,we read of it in the 4th chap. of Genesis, and 22d verse. We know that iron was exported from this country before the Roman invasion, and the ancient Britons must have understood how to work the metal for forming their scythes, hooks, spear-heads, and implements of warfare. Undoubtedly we owe our great wealth and prosperity as a nation, to our endless supply of iron and coal. It is less than 100 years ago, however, that iron was first used in engineering structures. The very first iron bridge constructed in this country, was, I believe, the bridge at Coal Brook Dale over the Severn, built 92 years ago, consisting of semi-circular cast iron arched ribs, and the bridge over the River Wear at Sunderland, built in 1790, of cast iron, would probably be the second.

Telford constructed many iron bridges, the first of which was that at Buildwas in Shropshire, across the Severn, in 1796, built of arched ribs of cast iron. His suspension bridge across the Menai Straits was commenced in 1825. Rennie's Southwark Bridge over the Thames was commenced in 1815. It was at the time, and even still is, I believe, the largest cast iron span, that of the centre arch being 240 ft. It was not until about the year 1832, that the first attempts were made to substitute wrought for cast iron, by riveting rolled plates together and forming girders by means of riveting horizontal to vertical plates with angle iron. (Though wrought iron plates had been used in the manufacture of steam-engine boilers, and ships, many years previously; the first iron boat having been constructed in 1822, at the Horseley Iron Co.'s works at Tipton.) But girders so made were used only in the construction of floors or as deck beams in ships, until about 10 years later, when Sir William Fairbairn patented several improvements and designed the tubular girder. The first tube of Robert Stephenson's great bridge, the Britannia, over the Menai Straits, was commenced in 1847, and the bridge was completed in 1850. The Conway Bridge was built about the same time, and since then, owing to the great success of these works and the numerous experiments that have been made with iron, and the improvements that have taken place in its manufacture, wrought iron has been most extensively used for every kind of engineering work, but more particularly for bridges. On our old railways, how few iron bridges there are, and on our new railways how few stone, brick, or timber bridges, but almost all iron. Our architects are now also using iron to a very great extent in their buildings. In the Northwestern Hotel, just completed at Lime-street station, Liverpool, Mr. Waterhouse has used wrought iron girders for all the floors, passages, galleries, staircases, etc., and cast-iron columns. Our fine old ships also, three-decker men-of-war, "the good wooden walls of old England" are now fast becoming a thing of the past, and are being replaced by a magnificent fleet of iron armor-plated vessels, and all these transformations have taken place within the last few years. A bridge, pier, breakwater, lighthouse, etc., built of iron would be, as we all know, about half the cost of the same built of stone; but we know that the stone will stand for centuries if properly constructed, and with good foundations, whereas we do not feel quite so sure about the iron, as to its durability, not

* A paper read before the Civil and Mechanical Engineering Society.

having had the experience of it. Although experiments of all kinds have been made by some of our most eminent engineers, to ascertain the specific gravity, tenacity, crushing force, and the breaking weights and deflections, etc., of different kinds of iron, various shaped girders, etc., yet no really definite conclusion as to the exact durability of iron in engineering structures. can be arrived at, though we can conjecture with tolerable certainty. Iron in its three different states or forms, viz., wrought iron, steel, and cast iron, though considerably lighter than most other metals, as copper, brass, lead, etc., is by far the most tenacious of all them. An iron wire $\frac{1}{36}$th of an in. in diameter will bear a weight of 60 lbs.

The tenacity of steel in lbs. per sq. in. is			......	120,000
" "	wrought iron	" "	......	70,000
" "	cast-iron	" "	......	19,000

But the time not permitting, and the subject of this paper being the durability of wrought and cast iron, I must exclude steel, though I believe the time is not far distant when it will be extensively used in engineering constructions. Some hundreds of miles of rails on the London and North Western Railway, have during the past year or two been relaid with steel rails. Mr. Kirkaldy has for some years been making a series of experiments on the resistance of plates of steel to crushing force, and Mr. George Berkley, in a paper read before the Institution of Civil Engineers, about this time last year, drew attention to the experiments which had lately been tried with steel, more especially Bessemer steel, which experiments he considered justified the adoption of the following conclusions :—

1. "That Bessemer steel would bear before rupture a minimum tensile strain of 33 tons per sq. in. of section, and stretch about 1 in. in 12 in. of its length.

2. "That the same material would bear, either in tension or in compression, a minimum stress of 17 tons before the extensions or reductions of length per unit of strain became irregular or excessive as compared with those which had preceded them; in other words, before the yielding point of the material was reached.

3. "That this material would probably contain about 45 per cent. of carbon, chemically combined with the iron; and,

4. "That this description of steel, if properly made and annealed, was as uniform in quality as wrought iron, and therefore might be employed (precautions being taken to test its quality as a substitute for wrought iron), while allowing an increase of strain of 50 per cent. to be imposed upon it."

Of the innumerable ores and the various formations in which iron is found, and of the preparation and smelting of the ores, etc., I will not now speak, but will at once proceed to the question as to the durability of iron, and the effects that the atmosphere, moisture, smoke, sea-water, changes of temperature, etc., have upon it. There is not the slightest doubt that iron absorbs to a certain extent the oxygen or the carbonic acid in the atmosphere, and gradually corrodes, and more so when subjected to changes of atmosphere, or exposed to the action of water, and especially sea-water. Other metals, such as copper or lead, when soldered or placed in contact with iron, act chemically upon it, and the iron more quickly softens and corrodes. For instance, the iron railings round the parks and squares, and round the areas of houses, etc., invariably begin to corrode at the bottom, where they are bedded into the stone with lead. I was noticing the railings round Leicester Square the other day; the iron at the bottom is, in many cases, entirely worn away or eaten to the thickness of a thin wire. Then again, the cast-iron plates which were affixed, according to Sir Humphrey Davy's proposition, to the bottom of ships to protect the copper sheathing, very rapidly became softened, and the ordinary copper sheathing fastened to ships by means of iron rails invariably begins to corrode, as do also the nails, at the places of contact by galvanic action. Sea-water has the effect both of softening iron and oxidizing it, but the rate of oxidation is slow. Mr. Mallett states, after making several experiments, that "cast iron freely exposed to the weather at Dublin, and to all its atmospheric precipitations, was corroded nearly as fast as if in clear sea-water, when the specimens in both cases were wholly unprotected." Doubtless, if the iron is always entirely under water, oxidation goes on more slowly than when the metal is exposed alternately to air and water. However, as I before observed, the rate of oxidation is slow. The cast-iron piles that the late Sir William Cubitt cased the entrance basin of the

Lowestoft harbor with in 1832, are now almost as perfect as when driven. The cast-iron piles for Herne Bay pier were driven in 1838 by Telford, and those for Southend pier in 1844, and are still in a most perfect state, as also Rennie's dock gates at Sheerness. The cast-iron piles in Margate jetty, erected in 1853, the wharf wall at Victoria Docks, the piers of Chelsea Suspension Bridge, of Charing Cross Railway Bridge, and of Lambeth Bridge, etc., show little or no signs of corroding. The latter, however, are in fresh water. Sea-water itself frequently provides an excellent protection against oxidation to the iron in the shape of mollusks, which little shell fish completely cover and incrustate the metal, and when this incrustation has been removed, the iron has been found to be smooth and quite free from any deterioration by the action of the sea-water. The *softening* of cast iron, Mr. E. B. Webb tells us, in a pamphlet on "Iron Breakwaters," is a process not clearly understood. He says, "cast iron will soften in cylinders and pipes used in mines, as well as in piles standing in sea-water; after softening under sea-water it will at times become hard again on exposure to the air." Cast iron *has* been taken up after immersion in sea-water, utterly decomposed, owing most probably to the iron having been cast of the softest metal, there being such great variety in the quality of cast iron. Great care should therefore be taken in selecting a quality of iron suitable for the work in which it is to be used, as the power of the various classes of cast iron to resist the action of sea-water, will vary according to quality. The necessity of substituting iron for wood or stone, in piers, lighthouses, breakwaters, etc., is due to the perishable nature of the former and the costliness of the latter. Mr. Webb in his pamphlet says: "It appears that the action of the sea-water is powerful in the greatest degree, when the iron is composed of large crystals, and especially when there is irregularity in the crystallization. It may be said that the softer the iron the greater is the liability to decomposition. Between the limits of extreme softness and decay on the one hand, and extreme hardness and durability, with brittleness, on the other, we have to make the selection. It has been stated that chilled cast iron corrodes faster than green sand castings, that all castings intended for use in sea-water should be cooled in the sand to insure uniformity in the crystals, and that Welsh iron is the best."

I will now turn to that portion of my subject which I think will be of most interest, viz., the application of cast and wrought iron to bridge construction. Wrought iron, as I before stated, was not, until about 30 years ago, employed in bridge construction, though cast iron has been made use of for nearly 100 years. Now, however, cast iron is not employed as much as formerly, for although cast iron has greater power to resist crushing strains, and is therefore preferable for columns, supports, and struts, etc., the crushing force of cast iron in lbs. yer sq. in. being about 92,000, and that of wrought iron about 38,000, yet for girders for bridge construction, the same amount of dependence cannot be placed in it as in wrought iron.

Mr. Rennie, some years ago, made a series of experiments on the effect of the changes of ordinary temperature on cast iron, particularly on the cast-iron arches of Southwark Bridge, which is the largest cast-iron span, I believe, that there is, and he found that the rise in each arch, the span being 240 ft., and the versed sine 23 ft. 1 in., is about $\frac{1}{40}$ of an in. for each deg. of Fahrenheit, making $1\frac{3}{4}$ in. for a difference of 50 deg. The arches have no alternative but to rise or fall, being bedded against the abutments. Cast-iron arches are of course on the same principle as stone or brick arches, and derive their strength and stability by transferring the effect of the loads placed upon them to the abutments. Cast iron is chiefly now, however, used in bridge construction in the form of horizontal girders, and especially on railways, where we are frequently pinched for headway, as the depth of the structure is merely that which is required for the flanges of the girders.

40 ft. is generally considered the maximum span for cast-iron girders, but the practice on the London and North Western Railway latterly has been, never to employ cast iron for spans over 25 ft. It is certainly not so safe as wrought iron, and the same degree of dependence cannot be placed in it. When testing the girders at the foundry, it is impossible to tell whether an extra ton of strain to the amount applied, would not have broken

them. Then we can never be quite sure of perfect castings, of perfect uniformity in the flanges, of the absence of air bubbles, etc. Then, again, in 9 cases out of 10, girders are cast on their sides at the foundry, in order to save time and trouble, and the consequence is that one edge of the flange, as also one side of the web, consists of the scum of the iron; and another great objection to this mode of casting is the difficulty of preventing lateral twists in the girder. By having the girder cast upright, standing on its bottom, all this is avoided; the spurious part of the iron will be in the top flange, where it is of not much consequence, and the girder is more likely to be perfectly straight. In my opinion engineers should always have a special clause inserted in their specifications, insisting on the girders being cast upright. The cheapness of cast iron is in its favor, being about half the cost of wrought, but the cost of wrought iron *now*, is even less than I have known cast iron to be, the prices fluctuate so very much. On the widening of the Trent Valley Railway, on which I am the resident engineer, the price of wrought-iron girders, including riveting, testing, painting, and fixing complete, is only £13 10s., whereas in 1861, the price for the cast-iron girders, on the Edge Hill and Garston Branch Railway was £13 10s. Since I have been an assistant engineer on the London and North Western Railway, during the last 10 years, the prices of iron work have varied from £22 to £13 10s. per ton, for wrought-iron girders complete in every way, for bridges of ordinary spans, and from £13 to £7 per ton, for cast-iron girders complete in every way, the lower prices being those of the present time. In practice, however, the difference in cost between wrought and cast iron is not after all so great, as owing to the thick flanges of cast-iron girders, the weight of them is nearly double that of wrought-iron girders of the same size. It is found that wrought iron corrodes rather faster than cast iron. Mr. Mallett gives the relative oxidation in moist air as follows :—

Cast iron	.42
Wrought iron	.54
Steel	.56

He also states that the depth of corrosion of plates of Low Moor iron, as deduced from his experiments, would be in one century:

In clear sea-water	.215 of an inch.
In foul sea-water	.404 "
In clear fresh-water	.035 "

Mr. Baker, the engineer-in-chief of the London and North Western Railway, and Mr. Ramsbottom, the mechanical engineer, together with Mr. Lee, lately inspected and thoroughly examined the Britannia and Conway tubes, both externally and internally, and found the former bridge in excellent preservation, having been recently painted, but portions of the under side of the cellular top of the Conway tube, which had not been painted for four years, and which caught the smoke of the engine chimneys, showed very slight signs of corrosion. They had some of the "scale" removed from the plates, and Dr. Percy analyzed it and found it to contain about 41 per cent. of metallic iron. The accompanying table shows the details of analysis :

SCALE FROM THE CONWAY TUBE.

First analysis of Dr. Percy from the two following samples, which were rubbed and scraped from one and the same area of the same plate:

No. 1.

From that rubbed off an area of plate 2′.4″×1′.9″.

	Grains.
Total weight	2,810.7
Containing	1,229.9 of iron

or 43.65 per cent of metallic iron.

No. 2.

From that scraped off an area of plate 2′. 4″×1′.9″.

	Grains.
Total weight	1,316.3
Containing	532.8 of iron

or 40.48 per cent of metallic iron.

Detail of Composition.	Per cent. of total of the above quantity.
Peroxide of iron	58.43
Protoxide of iron	3 34
Metallic iron	0.15
Protoxide of lead	2 29
Copper	traces.
Sand (chiefly silica)	10.90
Carbonaceous matter (soot)	4.97
Water	15.23
Sulphuric acid	3 30
	98.61
Peroxide of iron	54 90
Protoxide of iron	2.64
Metallic iron	traces.
Protoxide of lead	1.11
Copper	traces.
Sand (chiefly silica)	14 95
Carbonaceous matter (soot)	5.70
Water	15.65
Sulphuric acid	4.14
	99.09

Second analysis by Dr. Percy, from the two following samples, which were rubbed and scraped from one and the same area of the same plate:

No. 1.

From that "rubbed" off an area of plate 3′ 0″ × 1′.9″.

	Grains.
Total weight	4.614.
Containing	1,912.1 of iron

or 41.44 per cent. of metallic iron.

No. 2.

From that "scraped" off an area of plate 3′.0″×1′.9″

	Grains.
Total weight	5,703 3
Containing	2,255.7 of iron

or 39 55 per cent. of metallic iron.

The plates from which the rust was taken are ½ in. thick, and Mr. Baker says, that assuming the whole of this percentage did belong to the original iron plates, it would lead to the conclusion that under a continuation of similar circumstances, a period of time amounting to upwards of 1,200 years would be required for the entire corrosion of the plate. Messrs. Baker and Ramsbottom recommend that the painting of the tubes from time to time be continued whenever the paint shows the least symptoms of decay, and that the paint selected for this purpose should be of a first rate quality, and analyzed before being used, to see that it does not contain any matter injurious to the iron, and with such precautions they cannot give any practical limit to the endurance of these magnificent structures. These bridges have been built about 20 years. The sensibility to changes of temperature of the tubes of the Britannia Bridge, owing to their large surface, is very remarkable. The tubes become curved towards the point from which the sun shines, so much so, that between sunrise and sunset the centre is lifted fully an inch, as well as drawn sideways throughout an equal space. The total length of the Britannia tubular bridge is 1,513 ft., and an increase of temperature of 26 deg. Fahrenheit only causes an increase of length of 3¼ in.

Professor F. Grace Calvert, at a recent meeting of the Manchester Literary and Philosophical Society, read a most interesting paper on the oxidation of iron. He gave the results of a series of experiments he had made, at the instigation of Sir Charles Fox, to prove whether the oxidation of iron is due to the direct action of the oxygen of the atmosphere, or to the decomposition of its aqueous vapor, or whether the very small quantity of carbonic acid which it contains determines or intensifies the oxidation of metallic iron? The conclusions he arrived at are that "pure and dry oxygen does not determine the oxidation of iron, that moist oxygen has only feeble action; dry or moist pure carbonic acid has no action, but that moist oxygen containing traces of carbonic acid acts most rapidly on iron, giving rise to protoxide of iron, then to carbonate of the same oxide, and last to a mixture of saline oxide and hydrate of the sesquioxide of iron. These facts tend to show that carbonic acid is the agent which determines the oxidation of iron, and justifies the assumption that it is the presence of carbonic acid in the atmosphere, and not its oxygen or its aqueous vapor, which determined the oxidation of iron in common air. Although this statement may be objected to at first sight, on the ground of the small amount of carbonic acid gas existing in the atmosphere, still we must bear in mind that a piece of iron when exposed to atmospheric influences comes in contact with large quantities of carbonic acid during twenty-four hours." Professor Calvert ends his paper by stating as a fact "that carbonic acid promotes oxidation," and that "caustic alkalies prevent the oxidation of iron." He also states "that the carbonates and bicarbonates of the alkalies possess the same property as their hydrates," and "that if an iron blade is half immersed in a solution of the above mentioned carbonates, they exert such a preservative influence on that portion of the bar which is exposed to an atmosphere of common air (oxygen and carbonic acid), that it does not oxidize even after a period of two years. Similar results were obtained with sea-water to which had been added carbonates of potash and soda."

Mr. Baker usually has all wrought iron work immersed in boiling linseed oil before leaving the manufactory, and afterwards painted with four or five coats of best oil paint, in order to protect the iron from rust. In most of his specifications he has a special clause to this effect. There is not the slightest doubt but that, if the above was always done, it would effectually keep the iron from corroding for many years, and after a lapse of time, when signs of oxidation began to appear, if the iron was again carefully cleaned

and repainted, corrosion would be entirely prevented. But very often the above precautions are not taken and the iron does not get thoroughly painted, and frequently there is rust on the iron before receiving the first coat of paint. A resident engineer cannot be too careful in seeing to these matters. There are numerous anti-oxidation paints, one of the best of which, I believe, to be Hubbuck's patent white zinc paint, as "by virtue of a semi-galvanic action on iron, it enters the pores and forms an amalgam of the two metals, which protects the iron from decay or incrustation." The old Hungerford Suspension Bridge was in 1853 painted with the above, and it effectually preserved the iron from corrosion for 10 years, up to the time of its being pulled down for the new Charing Cross Railway Bridge. Another very good paint, from all accounts, is a silicated paint, supplied by "the Native Silicate Paint Company," as it causes the "substance of the paint to petrify" round the metal, and so preserve it, and it is said not to peel off. Small box girders, or tubular girders with cellular tops are objectionable on account of the large extent of surface exposed to corrosion, and of the difficulty there is in painting the inside; but by stopping up the ends of the cells so as to exclude the changes of atmosphere and moisture, the work of corrosion may be greatly diminished. One quarter of an inch, Mr. Stoney says, "may be assumed to be the minimum thickness that experience sanctions for the plating of permanent structures. A thinner plate than this may with care last for years, but few engineers would wish to risk the stability of any important structure on the chance of such frequent attention to prevent corrosion as so great a degree of tenuity would require."

The most important question of all, however, with respect to the durability of wrought-iron girders for bridges, etc., is, the amount of power of resistance that iron has to withstand repeated strains. It is of even more consequence than corrosion, and until lately has not been considered at all.

Sir William Fairbairn has recently been giving his attention to the subject, and making experiments to ascertain to "what extent vibratory action, accompanied by alternate severe strains, affects the cohesive force of bodies. It is immaterial whether the body be crystalline, homogeneous, or elongated into fibre, such as cast or wrought iron; the question to be solved is, how long will a body of this description sustain a series of strains produced by impact (or the repeated application of a given force) before it breaks? In the case of bridges and girders, this is a subject on which no reliable information has yet been given which may be considered as a safe measure of strength for the guidance of the engineer or architect." Sir William goes on to say, "of the resisting powers of material under the severe treatment of a continuous change of strain, such as that which the axles of carriages and locomotive engines undergo when rolling over iron jointed rails and rough roads, we are very imperfectly informed. Few facts are known, and very few experiments have been made bearing directly on the solution of this question. It has been assumed, probably not without reason, that wrought iron of the best and toughest quality assumes a crystalline structure when subjected to long and continuous vibration, that its cohesive powers are much deteriorated, and it becomes brittle, and liable to break with a force considerably less than that to which it had been previously subjected. This is not improbable, but we are apparently yet ignorant of the causes of this change; and the precise conditions under which it occurs." The breaking weight of wrought iron varies, as we all know, from about 20 to 24 tons per square arch of section, and the Board of Trade requirement in a wrought-iron bridge is that "the greatest load which can be brought upon it, added to the weight of the superstructure, should not produce a greater strain on any part of the material than 5 tons per sq. in."

It is usual in specifications to state the particular description of iron to be used, and the amount of strain per sq. in. it is required to sustain without having its elasticity injured, and also the amount before fracture, and it is also usual for the engineer to have samples of the plates tested. Mr. Baker and Mr. Stevenson generally now have specimens forwarded to Mr. Kirkaldy for testing and experimenting upon. When examining wrought-iron girders at the works, I generally carry a stamp with my name on with me, and mark a plate with it, or a T or L iron, which I have cut out and tested, in order

to ascertain if the same quality of iron has been used for the girders as was previously tested and approved of for the work. A soft, tough iron, if broken gradually, gives long silky fibres of leaden-gray hue, which twist together and cohere before breaking. A medium even grain with fibres denotes good iron. Badly refined iron gives a short blackish fibre on fracture. A very fine grain denotes hard steely iron, likely to be cold, short, and hard. Coarse grain, with bright crystallized fracture or discolored spots, denotes cold short, brittle iron, which works easily when heated and welds well. Cracks on the edge of a bar are indications of hot short iron. Good iron is readily heated, is soft under the hammer, and throws out few sparks.

Sir William Fairbairn considering the Board of Trade requirement of 5 tons per sq. in. not sufficiently definite to secure in all cases the best form of construction, and that the margin for errors of design and other practical defects being hardly sufficient, had a girder made purposely for experimenting upon of 20 ft. span, and of the following dimensions:—

Top plate 4 in. $\times \frac{1}{2}$ in.
2 angle irons $2'' \times 2'' \times \frac{5}{16}''$.
Bottom plate 4 in. $\times \frac{1}{4}$ in.
2 angle irons $2'' \times 2'' \times \frac{3}{16}''$.
Web plate $\frac{1}{8}''$ thick.

Depth of girder 16 in., weight of it 7 cwt. 3 qrs., and breaking weight 12 tons.

Sir William Fairbairn, in order to arrive at correct results, and to imitate as nearly as possible the strain to which bridges are subjected by the passage of heavy railway trains, invented an apparatus specially adapted for that purpose, and designed to lower the load quickly upon the beam in the first instance, and subsequently to produce a considerable amount of vibration,

From the experiments made it was ascertained "that wrought-iron girders of ordinary construction are not safe when submitted to violent disturbances with a load equivalent to $\frac{1}{3}$ the weight that would break them. They, however, exhibit wonderful tenacity when subjected to the same treatment with $\frac{1}{4}$ the load ; and assuming that an iron girder bridge will bear with this load 12,000,000 changes without injury, it is clear that it would require 328 years, at the rate of 100 changes per day before its security was affected. It would, however, be dangerous to risk a load of $\frac{1}{3}$ the breaking weight upon bridges of this description, as according to the last experiments, the beam broke with 313,000 changes ; or a period of 8 years, at the same rate as before, would be sufficient to break it. It is more than probable that the beam might have been injured by the previous 3,000,000 changes to which it had been subjected ; and assuming this to be true, it would then follow that the beam was progressing to destruction, and must of necessity at some time, however remote, have terminated in fracture."

The following tables show the summary of results obtained by Sir William Fairbairn's experiments :

First Series of Experiments.

Beam 20 ft. between the supports. Breaking weight 12 tons.

No. of experiment.	Date.	Weight laid on middle of beam in tons.	Number of changes of load.	Strain per square inch on bottom flange.	Strain per square inch on top flange.	Deflection in inches.	Remarks.
1	From March 21 to May 14, 1860.	2.96	596,790	4.62	2.58	.17	
2	From May 14 to June 26, 1860.	3.50	403,210	5.46	3.05	.23	
3	From July 25 to July 28, 1860.	4.68	5,175	7.31	4.08	.35	Broke by tension at a short distance from the centre of the beam.

The number of 1,005,175 changes was attained before fracture, with varying strains upon the bottom flange of 4.62 tons, 5.46 tons, and 7.31 tons per sq. in.

SECOND SERIES OF EXPERIMENTS.

Beam 20 ft. between the supports. Breaking weight 12 tons.

No. of experiment.	Date.	Weight laid on middle of beam in tons.	Number of changes of load.	Strain per square inch on bottom flange.	Strain per square inch on top flange.	Deflection in inches.	Remarks.
4	August 9, 1860..	4.68	158	7.31	4.08	—	The apparatus was accidentally set in motion.
5	August 11 and 12.	3.58	25,742	5.59	3.12	.22	
6	From Aug. 13, 1860, to Oct. 16, 1861...........	2.96	3,124,100	4.62	2.58	.18	
7	From Oct. 18, 1861, to Jan. 9, 1862...........	4.00	313,000	6.25	3.48	.20	Broke by tension as before, close to the plate riveted over the previous fracture.

Here the number of 3,463,000 changes was attained when fracture ensued.

From these tables it is evident that wrought-iron girders, when loaded to the extent of a tensile strain of 7 tons per sq. in., are not safe, if that strain is subjected to alternate changes of taking off the load and laying it on again, provided a certain amount of vibration is produced by that process; and what is important to notice is, that from 300,000 to 400,000 changes of this description are sufficient to insure fracture.

It must, however, be borne in mind that the beam from which these conclusions are derived had sustained upwards of 3,000,000 changes, with nearly 5 tons tensile strain on the sq. in., and it must be admitted from the experiments thus recorded that 5 tons per sq. in. of tensile strain on the bottom of girders, as fixed by the Board of Trade, appears to be an ample standard of strength.

Mr. Baker specified that the iron-work of the bridge over the river Mersey at Runcorn, which is one of the largest and finest of the bridges in this country, "should be of such quality as shall bear a strain of at least 14 tons per sq. in. of sectional area, without having its elasticity injured, and under this strain the extension of a bar 12 ft. long by 10″ by 1″ shall not exceed $\frac{1}{8}$ of an in., and fracture shall not take place under any strain less than 22 tons per sq. in. of section."

Mr. George Berkley, in a paper read before the Institution of Civil Engineers, this time last year, stated "that the strength of wrought iron varied with the quantities of work involved in the production of the form of the material tested. This was proved by the fact, that a bar of iron 1 in. sq., which would break with a strain of 26 tons, would, if drawn down to the form of wire $\frac{1}{32}$ of an in. in diameter, bear a strain of 40 tons per sq. in. The strength to be relied on in practice would probably be best represented by the minimum strain that 1 sq. in. would bear without rupture, and by the amount of stretch which would take place in a given length before it broke."

Simplicity of construction is the great point to be aimed at in designing wrought-iron girders. All plates and parts of girders should be of the same pattern, easily put together, and accessible for preservation or repair. All rivet-holes should be drilled, as punching the plates undoubtedly weakens them, by straining the fibres of the metal ; and all the ends and edges of plates and the butt joints of angle irons should be planed.

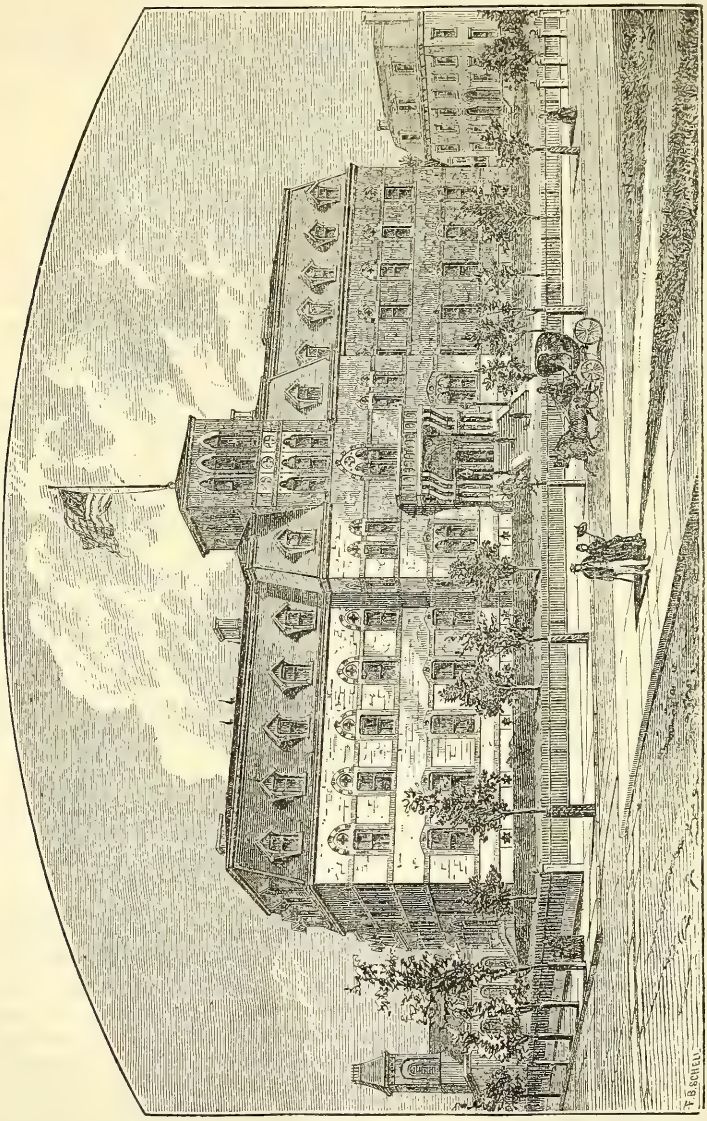
The resident engineer should himself see that all this is properly done at the ironworks ; otherwise, with the present system of letting contracts to the lowest tender, and the contractor again in his turn sub-letting the iron-work to the lowest tender, inferior iron will be used, and rivet-holes will be punched, plates not planed, etc.; in short, bad work executed in every way, in order to make it pay.

So the resident engineer cannot be too careful in thoroughly looking after these matters, remembering the enormous responsibility on his shoulders, where the lives of the public are at stake.

STEVENS INSTITUTE OF TECHNOLOGY, HOBOKEN, N. J.

We have the pleasure of giving below an engraving of the Stevens Institute of Technology, at Hoboken, N. J.

As the only special school of Mechanical Engineering in America, the institution excites unusual interest in our readers, and we intend, in a later issue, to describe fully this fine school, its workshops, laboratories, and apparatus, and the proposed course of instruction.



We can here only state that the school approaches somewhat in its character the technical schools of Germany, the aim of its founder and its managers being to combine, as far as it may be done in the schools, the practical with the theoretical, the experimental with the rational. It is with this object in view, that high scientific instruction is intended to be offered to the student, while at the same time

actual manipulation of tools and apparatus will be taught in the workrooms and in the chemical and physical laboratories, and a familiarity with science and its relations to the arts will be thus communicated, that can in no other way be attained.

We trust that it will not be many years before the graduates of such schools shall destroy the force of the statement now so often heard, that our scientific men very generally know nothing of every-day work, and our practical men too often exhibit a shameful ignorance of the scientific principles involved in their own work. He who most successfully combines theory and practice, as those words are usually but unfortunately used, is the successful engineer of the future.

IRON AND STEEL NOTES.

NOTWITHSTANDING the continual development of the iron trade in the United States—one of our best customers—there does not seem to be the slightest probability of our business transactions with America being affected. The demand is greater than ever; and as long as the American ironmaster requires $75 per ton for bar iron to make it worth his while to manufacture, we shall be sure of a market there. In 1870 we sent to the United States 45 per cent. of all the bar iron consumed. And as to the old gossip about the Americans importing our iron and steel for the purpose of making up into tools and machinery, and sending them to our markets in successful competition with our own manufacturers, we do not believe a word about it. Where such has been done it has been in a market where our cheapest, and of course our commonest articles have been sent, and as the American tool is generally a good one, it has been preferred to ours. If our merchants would send abroad our very best made goods, and be satisfied with a moderate commission, a different result would be apparent. As it is, they cannot compete with us in price, neither can they in quality. Therefore our ironmasters and manufacturers have no reason to be afraid of American competition. Another of our great customers, the Russian Empire, continues still to buy largely in our markets, and seems likely to make increasing demands upon us. Iron manufacture there does not seem to thrive. In Germany, just before the war broke out, a very large trade was being done in both coal and iron. It is said that the production of coal in Germany for 1860 amounted to 12,347,828 tons, of 2,000 lbs., and in 1869 to 26,774,368 tons; an increase in that time of over 14,000,000 tons, or equal to 117 per cent. This favorable result is still further enhanced to the trade by the advance in prices. Thus the money value in 1860 was 23,379,199 thalers, and in 1869, 51,928,403 thalers, giving an increase of 25,549,204 thalers, being equivalent to 97 per cent.; of this amount Prussia produces 88½ per cent.; Saxony, 9½ per cent.; Bavaria, 1⅛ per cent.; and the remaining States ¼ per cent. The exports of German coal in 1869 amounted to 4,000,000 tons, of which France took 1,700,000 tons, the Netherlands, 1,300,000 tons; and the imports were 1,800,000, making the home consumption 25,000,000 tons. These figures show the steady growth of this industry, and also that of iron, which is the most closely allied to the coal trade. The consumption of coal in Germany has risen 9½ per cent. per head of the population since 1860, while the population itself has only increased in the same time about 14½ per cent. The product for 1870 will fall off considerably from the war in France, which checked industry, depriving the collieries and iron-works of hands, and will have a somewhat similar effect upon 1871, the first half of which has been almost lost. The prices of pig iron per ton in Germany to-day are:—Foundry No. 1, 28 to 40 thalers; No. 2, 36 to 37 thalers; Gray Forge, 32½ to 33 thalers; White and Mottled, 32 to 32½ thalers. Manufactured iron is quoted high, bar being 72 to 76 thalers per ton. The high price of coal has equalized the losses on production, and collieries have generally paid 10-20 thalers per cent. for it upon their capital. One of the effects of the cession of French territory to Germany is noteworthy as including in the portion ceded 25 iron furnaces, with a production of 204,579 tons a year, and collieries with a yearly product of 506,640 tons. Thus there is not much to fear in the shape of German rivalry. They have got to put their house in order before they can begin the race with us. As for unhappy France, it is impossible to say what she is likely to do. It is said that the Government contemplates levying heavy import duties upon all raw materials, this will be sure to provoke bad feeling with the manufacturers of that country. Little Belgium is busy doing her best, but her largest production is so small as not to affect our market. Therefore from none of these quarters are we likely to be hindered in our trade, and both iron-master and iron-worker may look forward with confidence to the future. The reports which we have received from the various iron-making districts are still of an encouraging character; and the markets of Glasgow, Middlesbro', Wolverhampton, and Birmingham, as well as those of South Wales, are firm as to prices, and full of lively anticipation for the future.—*Iron Trade Circular.*

IRON AT LOW TEMPERATURES.—At a recent meeting of the Philosophical Society of Manchester, several communications were submitted, dealing with the influence of low temperature in producing brittleness in iron and steel. Mr. Wm. Brockbank contributed a paper on this subject. The author stated that he had instituted a series of experiments for the purpose of ascertaining the effects of cold upon the strength of iron. He found that by using a mixture of metals consisting of Cleator hematite, Pontypool cold blast, Blaenavon cold blast, and Glengarnock hot blast, with some good scrap iron, a considerable decrease of strength in the bars was perceptible as the temperature decreased. The experience of several ironfounders as follows, was also adduced in confirmation of the results above named:—(1) Pig iron breaks most easily in frosty weather, and castings are also more liable to fracture at low temperatures. (2) Special care has to be exercised in rolling mills during frosty weather, to pre-

vent the breakage of rolls. (3) The cast iron wheels of the chaldron wagons, used on the Stockton and Darlington Railway, are found to fracture very frequently in frosty weather. From the evidence collected, the author concludes that the strength of cast iron is very materially lessened by severe cold. In his experiments with wrought iron, the author found the same general principal applicable. Mr. Bouch had demonstrated that a bar of round iron, 1½ in. in diameter, was far more brittle at a temperature of 26 deg., than it was at the ordinary temperature of the workshop. Mr. Peel, of Manchester, obtained corroborative results from tests applied to boiler plates. Railway bars had also been tested by the author at the Darlington Iron Works. It was found that rails of high quality failed to pass the requisite test in frosty weather, whereas, at ordinary temperatures, a failure with this class of rail was a very rare occurrence. The author, therefore, maintained that bar iron, boiler plate, wire billets, and rails are most materially weakened by the action of intense cold, losing their toughness, becoming quite brittle under sudden impact, and having their structures changed from fibrous to crystalline.

At the same meeting, Sir W. Fairbairn, F. R. S., communicated the results of his experiments upon the subject alluded to by Mr. Brockbank. He had found that the resistance to a tensile strain is as great at the temperature of zero, as it is at 60 deg. and upwards, until it attains a scarcely visible red heat. The mean breaking weight in tons, per sq. in., was (in his experiments) in the ratio of 1 to 1.098 in favor of the specimens broken at a temperature of zero. Referring to the frequent breakage of the tyres of railway wheels, he considered that the danger does not arise so much from sudden changes of temperature, as from the practice of heating the tyres to a dull red heat, and then shrinking them on to the rim of the wheels. The unequal, and in some cases severe, strains to which they are thus subjected, has a direct tendency to break the tyres.

Dr. Toule also contributed a paper on the same subject. He agreed in the main with Sir W. Fairbairn. His experiments had shown that wire, exposed to a temperature of 50 deg., was weaker than when tested at 12 deg. The general conclusion at which the author arrives is, that frost does not make either iron (cast or wrought) or steel, brittle; and that accidents arise from the neglect of the companies to submit wheels, axles, and all other parts of their rolling stock to a practical and sufficient test before using them.

Mr. Peter Spence made a short communication, setting forth that certain experiments he had made led to the conclusion that a reduction of temperature increases the strength of cast iron.

We clip from an "Exchange" the following account of the great steel rail mill of the Bethlehem Iron Company, at Bethlehem, Pa.:

The new steel rail mill at Bethlehem, Pa., now erecting by the Bethlehem Manufacturing Company, under the direction of John Fritz, their chief engineer and superintendent, will be, when done, the largest in this country, and one of the largest in existence. It consists of a building 105 ft. wide, spanned by an iron and slate roof without supporters. It is 30 ft. high to the eaves, and is in the shape of a cross, of which the long arm will be 900 ft., and the short arms 142 ft. each, making 1,184 by 105 ft. area, or nearly 3 acres covered. This is only surpassed by the mill at Creusot, in France, which consists of 3 buildings 60 by 1,400 ft. each.

The capacity of the works is to make 300 tons of steel ingots per day, but at present machinery will be erected for rolling but 100 tons of rails, or more than double the capacity of the largest mill yet erected. There will be 8 5-ton converters and 2 train rolls, one of 24 in. and 1 of 28 in. diameter, driven by 2 condensing engines of 48 and 56 in. diameter of cylinders, and 44 and 48 in. stroke.

This mill will be remarkable, not only for its enormous size and capacity, but for the many new labor-saving conveniences introduced into the design of the plant by the engineer, Mr. Fritz, who has examined personally all the Bessemer steel works both here and abroad before designing this.

It is the opinion of experts who have seen it that it will turn out more tons of steel rail, with less manual labor, than any other mill has ever done.

Cleveland Iron Works —The following is the statement of iron manufacture in 1870, in the city of Cleveland.

	TONS.
Pig iron	18,575
Rails, iron	39,367
Rails, steel	33.000
Rails, steel capped	3,056
Merchant iron	17,956
Boiler, tank and sheet iron	4,250
Forgings	5,775
Nuts, washers, bolts, nails, spikes	10,751
Machinery castings	27,900
Wire, iron and steel	2,160

The consumption during the year of pig and scrap iron was 125,800 tons, and of coal and coke, 372,500 tons. No new mills have been started, but most of those in existence have been extending their capacity.—*Marquette Mining Journal.*

William F. Roberts, Esq., State Geologist of Arkansas, claims for that State great advantages as an iron producer. He states in a letter to the Philadelphia "Press," that 17 years ago, under the auspices of a number of gentlemen living in Philadelphia and New York, he made a hasty examination of the mountainous regions of the State, and obtained satisfactory evidence of the wonderful mineral resources of the State. The money crisis of 1857, and the war following, prevented the execution of laid-out plans to develop them. In regard to coal, he states that although not generally known, there is an immense field in Arkansas.

"Although the limits are at present undefined, yet there are sufficient evidence from the *bared* outcroppings of the coal strata in various places, to show that the field is very extensive. The river Arkansas runs lengthways through this coal formation for more than 150 miles within the limits of the State, and it extends far westward into the Indian nation, and there are many places in Arkansas where the veins might be opened and economically worked above water-level. The advantages in this respect should enlist the attention of coal-mining capitalists of Eastern States to invest some of their surplus earnings in the purchase of coal lands in Arkansas.

"The light, free-burning anthracite found to exist, though in thin strata, in the eastern part of

the Arkansas field, gradually changes into a fat bituminous coal in the western part, where veins are exposed from 5 to 6 ft. thick. At Spadra, on the Arkansas river, 150 miles above Little Rock—river navigation—the coal is similar in structure and appearance to the Cumberland coal of Maryland, and its quality, by analysis, is similar to that famous article of fuel. It is true semi-bituminous—an excellent steam and manufacturing coal. In the upper or western part of the field is a good gas coal, and the bituminous, in some places in this part of the region, approaches the variety called cannel. The anthracite obtained was equally pure in quality, and of as bright, clear fracture as that of Pennsylvania, but this was got from the 'outcrop' of a small seam; larger and workable strata may yet be discovered, when more attention than has been heretofore is directed to the development of this as well as other valuable minerals, which hitherto have been neglected in this State. Cotton, not coal, has been the great attractive staple of Arkansas. In case a pure white ash anthracite does not exist to any great extent as a workable coal, it is certain that semi-anthracite and semi-bituminous do, and that any amount of this kind of fuel can be mined at cheap rates for supplying blast furnaces, rolling mills, and manufactories, to an almost unlimited extent, and for any reasonable time.

"The great coming staple of Arkansas industry, next to coal-mining, will be working the immense deposits of iron ore, which is in great abundance in many places. This State can, without exaggeration, boast of her iron-ore deposits, especially when we take into consideration the various kinds of ore, their generally rich quality, and enormous quantity. This fact is more generally known because it is seen on the surface in mass on the travelled roadsides. Her coal wealth is hid from view, and therefore not appreciated as it should be. Here are the magnetic, hematite, specular, spathic, calcareous, argillaceous, and other varieties of iron ore. Some of the magnetic deposits consist of perfect 'loadstones,' with strong attracting and repelling power, free from any deleterious foreign mixture, equal to the best known elsewhere, for manufacturing steel, and in quantity apparently inexhaustible. The 'limonete' beds in some places cover acres of surface, and where there is great abundance of the best kinds of timber for making charcoal, also limestone of the best quality for fluxing purposes. Never failing, large water-powers are contiguous to the iron ore deposits, and constant river navigation thence to the Mississippi. No State in the Union presents greater facilities for manufacturing charcoal iron economically than Arkansas, and there is a home market for a very large product."

RAILWAY NOTES.

THE NEW OHIO AND MISSISSIPPI.—We welcome this great line to the family of the standard gauges of our country. At an early afternoon hour of Sunday, Superintendent Griswold announced to the party accompanying him over the narrow gauge as it progressed :

"Gentlemen, I am happy to inform you that the Ohio and Mississippi Railroad is now a narrow-gauge road."

In 8 brief hours the long proposed and well-considered "new departure" had been made a fixed fact.

The Ohio and Mississippi road was completed in 1855. Sixteen years measures more than half in time, and practically the whole in progress, of our railway history. In it date all the improvements—in track, equipment, operation, and policies of transportation—which have raised the locomotive and the rail from a mere rude device of genius, to a perfect instrument, the fruit of accurate study, practical experience, and practised skill. In those early days of yesterday, whatever doubt there may have been in regard to the proper width of track inclined to the side of the now obsolescent broad gauge becoming by hastening steps a thing of the past. At any rate, 4 ft. 8 in. was not thought of as the "gauge of the future." It is since that date that the entire railway system of the South has been built up on a 5 ft. gauge. That, too, will have sooner or later to yield to the stern necessity of "the inevitable." It has now been for many years apparent that the 4 ft. 8 in. gauge would prevail ; and the wonder is, in view of the exacting conditions of close connections and through transportation which have of late years obtained, that even so splendid a system as that composed of the Erie, Atlantic and Great Western, and Ohio and Mississippi Railways, should have maintained itself.

It may be suggested that the necessity of the change, for some time recognized by the managers of the Ohio and Mississippi road, possesses a significance as respects what is the true sea-board objective of St. Louis commerce ; it is not New York, but Baltimore. Brief time will show. Baltimore people are prone to regard St. Louis as the true interior *entrepot* of the Western trade of their now ambitious and enterprising city. How far this is an opinion, warranted by a consideration of hard facts of topography and trade, and how far a sentiment born of the fellow-feeling of a recent but now forever past industrial and social system,—we shall not undertake to say. At all events, Baltimore now has what New York has long had—a continuous standard-gauge line of railway to St. Louis. The Baltimore and Ohio portion of this route is among the well-built, well-equipped, and well-managed great roads of the country. This latter Company, long content with the rich fruits of her consummate local policies, has very recently become convinced of the value of Western business, and the necessity of at once commanding it. Hence the control secured of the Marietta and Cincinnati road, which has during the past year, been re-created in the image of its master-spirit. Connection thus secured with Cincinnati, the very advantages for which it was secured could not be long sacrificed by the change of gauge, breaking of bulk, and transfer of passengers at that point. The struggle between the broad gauge and standard gauge interests—in a sense between New York and Baltimore,—for the control of the Ohio and Mississippi line would, doubtless, were its secret history known, form a striking chapter in the history of railway diplomacy and war.

With the progress already made in bringing the Marietta and Cincinnati to first-rate condition, and the excellence of permanent way which the Ohio and Mississippi can very soon attain, it will now be due to something besides equal facilities with other cities for travel and traffic west, if Baltimore does not hereafter keep neck and neck with

her competitors in the Western race. The St. Louis "Times" well notes, in its excellent description of the changing of the gauge, that it gives the Ohio and Mississippi 15 in. of additional bed, securing a track foundation not surpassed in this country by virtue of improvements constantly making during 15 years.

The details of the work of changing the gauge have been very fully laid before most readers in the daily press, and we shall only summarize them. Both rails were moved,—a manifest advantage to the road, over the usual process of moving one the entire $15\frac{1}{2}$ in. The inside spikes for the new track had been driven and the ties prepared for the rails; and the gauge had already been changed wherever, as on the sidings, it could be done without embarrassing traffic. Surveys had also been made of the entire line, and a table made of all the curves. For the purposes of the work of moving the rails, to each 5 mile section were allotted 40 men under a Superintendent, and foremen in charge of squads of a half-dozen men. One squad drew the inner spikes of both rails, another moved the rails up to the spikes already driven, and 20 or 30 men followed driving the outer spikes. The number of men immediately engaged was about 3,500, and the "job" was completed in 8 hours.

Up to Saturday night (inclusive) all trains ran through, the traffic of the road not being interfered with. It was no simple matter to keep all the broad-gauge trains, through and local, thus running regularly up to the very act of moving the rail, and at the same time to have the narrow-gauge stock all distributed so as to start trains at once, the moment the "new departure" was taken. Twelve o'clock Saturday night found all the old rolling stock laid up at 6 stations along the line of 340 miles; construction trains were, meanwhile, distributing 10 men to the mile, along the line; and daylight of Sunday saw every engine and car motionless, and the entire main track clear thereof for the only time in 16 years. The silence was, to railroad men, accustomed only to the movement or cars night and day, week day and Sunday,—like the darkness of Egypt—a silence that could be felt. One falls, in speaking of the whole affair, into the language of the battle field. The plans for action all perfectly laid, every company and squad in its place—the men lay for a few silent hours "on their arms" waiting for the dawn. At break of day, some of them at 3.30 A. M., all were "up and at it." By 9.20 the change had progressed sufficiently on the west end of the Road ($6\frac{3}{4}$ miles across the "American Bottom" being finished in 4 hours) that General Superintendent Griswold, accompanied by the other working offcers of the road, left with an engine and car to go over the new road.

For several months the machine shops of the road have been working to their full capacity altering rolling stock. The 3 roads now forming the through Baltimore and St. Louis line place 1,000 new cars on the route. The expenditures of the Ohio and Mississippi Railroad Company in the making of the change, including the preparation of the rolling-stock, will amount to $1,500,000. —*Chicago Railway Review.*

The Euphrates Valley Railway Scheme.—We have heard but little lately concerning the once absorbing topic of direct railway connection with India. No doubt the gradual perfecting and completion of the Suez Canal has had a great deal to do with this silence, by attracting the attention of the public from the more direct though inchoate scheme, to that actually put into practice. But the subject is renewed, and now we have the old proposal to construct a railway along the Euphrates Valley again brought prominently into view. In the House of Commons on Friday night Sir Geo. Jenkinson moved for a Select Committee to inquire into the whole subject of railway communication between the Mediterranean and the Persian Gulf, and the House ultimately decided by a large majority in favor of the Committee.

The suggestion to utilize the Valley of the Euphrates is not by any means new, nor is this the first time that motions have been made in connection with it in Parliament. We understand that as far back as the last century the Marquis of Wellesley endeavored to utilize the identical route; and at later dates the House has been asked to grant sums of money for various purposes in connection with it. In most, if not all these cases, money was an object, and was usually directly applied for; but in the present instance all that the mover asked for was an official inquiry which should end in placing upon record all the valuable information now available, including the evidence of Major-General Chesney and others. So far the object is perfectly legitimate and most desirable.

It is not supposed by the promoters of a railway to India that such railway would be in any way antagonistic to the Suez Canal, which would, in all probability, monopolize the heavy traffic, and still exist as the chief means of communication with Southern India. But, on the other hand, the Euphrates line would benefit the north-west provinces, and, as far as passengers and mails are concerned, would effect a saving in time of at least a fortnight, taking the voyage out and home. The saving in distance would be about 1,000 miles in a straight line, and, as vessels proceeding by way of the Red Sea are compelled to deviate from their courses to the extent of 500 or 600 miles during the monsoon months, the saving that might accrue, taking an average of voyages, would be somewhere about 1,000 miles each voyage. Then, on the other hand, the railway would always suffer, from the fact that two transshipments would have to be effected in every case, and this where the goods are bulky is a serious consideration. We have little doubt that any one having to send goods to India—say to Kurrachee—would prefer to send by way of the canal rather than by the railway, though he would save much in point of time by the latter, simply because of the necessary evil we have just pointed out. As a case in point, it was shown that prior to the opening of the Suez Canal goods only of small bulk were sent to India by way of the Isthmus Railway, although the voyage by the Cape occupied 80 days.

Besides the Euphrates Valley, two other routes are also pushed forward as deserving of examination. One of these consists in substituting the Black Sea for the Mediterranean, and making the terminus of the line at Trebizonde. By the champions of this scheme it is contended that the long and dangerous voyage necessitated by a Mediterranean terminus would be avoided by making use of the Danube and the short passage across the Black Sea. Here we have some serious objections to face. On the European side there is the liability of having the Danube, or indeed the Black Sea,

closed, the effect of which would be that the railway would be simply useless, as long as the restrictions remained in force; and on the Asiatic side there would be enormous practical obstacles in the shape of mountain ranges near Trebizonde. The second route is the Tigris Valley. It has been stated that along the Euphrates Valley there would be but little local trade, because after leaving Aleppo the railway would, for 700 miles, pass through a country sparsely populated, whereas by the Tigris Valley route it would open out a better country, and one peopled by more peaceable tribes. Of the respective advantages of the two routes in respect of facilities of construction, we are enabled to state from actual survey that the Valley of the Euphrates is perfectly flat, and that nothing better could be desired in the matter of level, while it is not easy to say what difficulties the Tigris Valley may or may not present. Mr. Eastwick has visited various parts of the Euphrates route, and he states that the facilities there for making a good road are great, and that in certain districts the local traffic would, in all probability, be very considerable. We have for the present simply confined ourselves to a statement of the three systems as they have been laid before Parliament. In our next article we shall have some something to say concerning the engineering points of interest in connection with them.—*The Engineer.*

THE CAR SHOPS OF THE HOUSATONIC RAILROAD — This Company, understanding the advantage of using cars built and repaired by themselves, have always maintained shops for this purpose at their southern terminus, in Bridgeport.

With a force of 14 carpenters, and the proper proportion of other mechanics, Mr. J. Ferris, the Master Car Builder, turns out about 75 cars a year, constructing every part in the shops of the Company.

In the construction of the floor framing, he bolts the bolsters to the under side of the longitudinal floor timbers, and thus avoids cutting into and weakening them.

The side-bearings are fixed at about half the usual distance from the centre bearing, under one of the intermediate longitudinal floor-timbers, thus allowing the truck to swivel more easily, and allowing of smoother motion of the car.

The Company has now 45 milk cars, which may be used indifferently for the transportation of milk or for ordinary freighting purposes. They are the usual box cars, but having, at the front and back ends, ventilating holes 3 in. in diameter, and about 6 ft. above the floor. Two ice-vats, each about 8 in. deep and 2 ft. wide, are provided, fixed about 4 ft. from the floor, extending quite across the car—one at each end. These vats are lined with zinc, and have a waste-pipe for conducting off the water from the ice. The air, entering at the ventilators, passes over the ice in the vats and then finds its way over the floor where the milk cans stand, thus effectually cooling them.

The Company is applying spring-cushioned backs (about 3 ft. 6 in. high) to the seats on one of their passenger cars. Two links are contrived, each hinged at one end to the back, at the other to the arm of the seat, so that the cushion may be turned in the ordinary space, a result which could not be effected in the common way, where there is only one link.

Mr. Ferris make use of a vulcanite emery-wheel for fitting his boxes. This wheel is a cylinder, a little longer than the box and a little less in diameter than the journal, and does its work quite rapidly and without perceptible wear. The boxes, while being ground, are occasionally tested on a mandrel to insure accuracy. Fitted in this way they seldom heat, whereas when they are finished with a file there is considerable trouble on this account.—*The Railroad Gazette.*

ILLINOIS CENTRAL RAILWAY LOCOMOTIVE REPORT FOR MARCH.

1871.	Chicago Division.	South Division.	North Division.	Iowa Division.	Total.
Miles of road	252½	230¾	225	401	1109¼
MILES RUN:					
By passenger trains	30,088	30,785	28,408	18,059	115,340
By freight trains	84,753	46,417	63,059	52,801	247,030
By other trains	20,814	12,397	3,787	15,871	52,869
Total miles run	143,655	89,599	95,254	86,731	415,239
COST PER MILE RUN:					
Oil, waste and tallow	.66	.71	.73	.54	.66
Wages	5.88	5.81	6.29	5.84	5.95
Repairs	9.75	7.74	11.95	7.45	9.34
Fuel	6.00	5.63	6.80	7.21	6.36
Cleaning	1.28	1.00	.99	.94	1.08
Total in cents	23.58	20.87	26.76	22.00	23.41
AVERAGE MILES RUN:					
To one pint of oil	13.54	12.84	11.72	18.71	13.64
To one ton of coal	37.64	38.25	31.84	39.13	35.92
Average number of passenger cars hauled per mile	5.09	4.53	4.66	3.52	4.45
Average freight do. do. do.	17.33	15.53	14.29	9.82	14.17

The above oil includes that used in head lights and in lamps of engineers. Wood is rated at $4.75 per cord; coal, $2.00 per ton on Illinois Central proper; on Iowa Division, wood $5.25 per cord; coal, $2.70 per ton, loaded on tenders; oil, 50 c. per gallon; waste 15c. per pound. Rebuilding, superintending, teaming, and all other expenditures appertaining to repairs, are included in the

above cost of performance of locomotives. Two empty cars rated as one loaded. Whole number of locomotives owned by the Company, 188.

Average cost per mile of passenger engines, in cents	17.86
Average cost per mile of freight engines, in cents	25 16
Average cost per mile of construction engines, in cents	14.42
Average cost per mile of switching engines, in cents	18.74

—*American Railway Times.*

CAR COUPLING.—Mr. John A. Mason, of Keokuk, Iowa, is taking measures to introduce a car-coupling of his invention, which, in general appearance, is somewhat similar to the Miller platform. There are compression buffers at the ends of the sills, immediately over the coupling hooks, and the coupling is effected by hooks which spring sidewise, as in Mr. Miller's arrangement. The springs, however, for keeping the hooks together and preserving the coupling, are not attached to the draw-bar, but are spiral springs placed on a vertical shaft, with a hand wheel, and from the shaft is an arm and link connecting with the hook.

The hook differs in form materially from Miller's, and no adequate idea of it can be given without a model or drawing. The inventor claims advantages for it, that automatic coupling may be effected though the cars vary 8 or 10 in. in height; that a much larger bearing surface is secured, and consequently a more reliable connection; that on curves there is no danger of uncoupling; that there is no transverse strain, or shearing stress, of the drawbar—and consequently it may be made much lighter—and that it is applicable to freight cars, and as much "slack" as necessary can be secured.—*Railroad Gazette.*

THE NEW YORK RAILROADS.—The Albany "Argus" prints some interesting figures from the report of the State Engineer of Railroads:

The number of roads operated by steam is 164.

The amount of capital stock paid in is \$234,225,159.

The total cost of the construction and equipment of steam railroads is \$249,228,896.

The length in miles of the steam roads in the State is 7,166. Length of roads laid 4,773.

Number of first-class passenger cars, 1,229 ; of freight cars, 34,051.

Number of passengers carried in cars run by steam, 24,550,753. Number of miles travelled by passengers or number of passengers carried 1 mile, 912,626,984.

Total amount of freight, or number of tons carried 1 mile, 2,654,146,549.

The number of passengers carried in city cars during the year was 154,591,871.

The total earnings of roads operated by steam amount to \$69,549,444.

A great deal is said about railroad accidents, and the dangers attending travel on railroad cars. The results of 1870 show that 15 passengers were killed by accidents. The average number of miles travelled for each passenger killed was 669,841,798.

According to this showing, the safest place for a person to live would be on a railroad train. The figures are correct, and yet a person might be killed during the first mile of his ride.

An examination of the figures given in the synopsis referred to will disclose other information equally interesting.

ENGINEERING STRUCTURES.

ILLINOIS & MICHIGAN CANAL—DEEPENING COMPLETED.—The deepening of the Illinois and Michigan Canal, whereby the waters of the lake take their tortuous course up the sluggish channel of the Chicago and into the Illinois river and so gulf-ward—the Chicago river virtually flowing up stream—has, as our readers are well aware, been finally and successfully completed. Our City Fathers, rightly estimating the value and importance of the event, determined upon its commemoration in a style worthy of it and of the city. Accordingly on Tuesday last 4 large canal boats, double decked, or roofed, for the accommodation of the immense crowd of guests invited to join in the festivities of the day, left their dock about 10 o'clock A. M., and in tow of powerful tugs steamed up—or down, more properly speaking—the river and into and down the canal as far as Lemont. The intention was to proceed to Lockport, where the citizens had made ready to welcome the visiting party in a most generous manner. But the unexpected loads, and the slow time necessarily resulting, determined the committee of arrangements to stop at Lemont.

At this point several prominent gentlemen well known as intimately connected with the canal-enterprise, made well received, although off-hand and impromptu addresses, and a very neat and appropriate poem was read.

Hon. C. C. P. Holden, President of our Common Council, having been constituted Chairman of the meeting, presided with his accustomed ease and dignity, and introduced the speakers.

Perhaps we cannot do better, to give an idea of the nature of the enterprise and the difficulties encountered in its prosecution, than present the substance of the speech of W. H. Carter, Esq., Treasurer of the Board of Public Works.

The canal was commenced in 1836 by the State, and so prosecuted till 1842. \$4,500,000 had been expended when the work was suspended. In 1845 it passed into the hands of trustees, who raised \$1,500,000 to complete it. The original plan was modified, and the high level with pumps, feeders, and locks substituted for a "deep cut." It was completed in the spring of 1848. In 1855 the city had become so large that it became necessary to adopt some system of sewerage; a difficult problem considering the location and low ground. It was finally concluded to adopt the present system, which has worked better than might have been expected; but the great trouble is, they discharge their foul contents into our river until it has become a vile cesspool, endangering health and depreciating the value of property along its margins. Public attention was aroused, and the question how best to cleanse the river was discussed at length. In June, 1868, the Common Council appointed a committee of engineers to examine and report as to the best method of cleansing it. The committee presented 3 plans, but especially recommended the deepening of the "summit" of the canal, which was the course finally entered upon. In September, 1866, the work was contracted and soon after commenced. After about

$200,000 had been expended in 1869, the work was suspended, and contracts abandoned. Then came the tug of war. The whole plan was violently assailed by a portion of the public press; friends of the enterprise began to grow cold; a portion of the Board of Public Works began to waver; the Council began to show signs of timidity. But the friends of the enterprise stood by it firmly. Wise and better counsels prevailed; the order of the Council was again made to proceed, only 2 members voting against it.

In the fall of 1868 the work was finally contracted again, and since then has been energetically prosecuted, especially during 1870, when nearly ½ the entire expenditure has been made.

Finally, on the 15th of this month, a little after 2 o'clock P. M., the coffer-dam that had for a time been holding the waters of the river was cut, and the waters of Lake Michigan took their "new departure."

The speaker paid a just tribute to the Commission—consisting of Messrs. Wm. Gooding and Col. Mason—who were appointed to act with the Board of Public Works in all matters pertaining to the work. Had they failed in 1867, when a portion of the people began to be desponding, and the batteries of the press were turned upon them, he had no doubt the work would have been abandoned. But standing firm and unflinching, they inspired courage, and the work went on.

"'Tis a consummation most devoutly wished for" by our citizens to see the clear, blue water of the lake taking the place of the foul and stagnant pool to which we have been so long accustomed, and for which the less sanguine have prophesied there could be but little or no effective relief. The current down the canal is a strong one, much to the disgust, by the way, of canal boat men, who are now obliged to redouble their tractive force to draw a boat counter to it. What effect the current may have upon the banks of the canal remains to be seen. Many practical men are of opinion that a gate, or lock, or check of some sort will be necessary to control it, especially at high water. But, inasmuch as machinery will probably soon be used on our canals, the other objections to the current will be reduced to a mere nothing.

The entire cost of the work has been $3,116,281.84; besides for pumping $66,729; discount on bonds $95,682. Tolls lost $43,913. Cubic yards of vertical wall constructed, 1,669; cubic yards of riprap, 24,418; extra work, 30,738 cubic yards.—*Chicago Railroad Review.*

The Great Steel Rail Mill in Bethlehem, Pa.—The new steel rail mill at Bethlehem, Pa., now erecting by the Bethlehem Manufacturing Company, under the direction of John Fritz, their Chief Engineer and Superintendent, will be, when done, the largest in this country, and one of the largest in existence. It consists of a building 105 ft. wide spanned by an iron and slate roof without supporters. It is 30 ft. high to the eaves, and is in the shape of a cross, of which the long arm will be 900 ft. and the short arms 142 ft. each, making 1,184 by 105 ft. area, or nearly three acres covered. This is only surpassed by the mill at Creusot, in France, which consists of three buildings 60 by 1,400 ft. each.

The capacity of the works is to make 300 tons of steel ingots per day, but at present machinery will be erected for rolling but 100 tons of rails, or more than double the capacityof the largest mill yet erected. There will be eight 5-ton converters and two train rolls, one of 24 in. and one of 28 in. diameter, driven by two condensing engines of 48 and 56 in. diameter of cylinders and 44 and 48 in. stroke.

This mill will be remarkable, not only for its enormous size and capacity, but for the many new labor-saving conveniences introduced into the design of the plant by the Engineer, Mr. Fritz, who has examined personally all the Bessemer steel works both here and abroad before designing this.

It is the opinion of experts who have seen it that it will turn out more tons of steel rails with less manual labor than any other mill has ever done.—*The Railroad Gazette.*

The Invention of the Steam Hammer.—The evidence of M. Schneider, before the Committee of the Patent Laws on the above invention, has given rise to an animated controversy. From a letter sent to a contemporary by Mr. James Nasmyth, we give the following extract:—"It was on the 23d of November, 1838," writes Mr. Nasmyth, that the first conception of my steam hammer occurred to me, and on account of the simplicity which characterizes this important invention, my first design of it was made out within an hour after; and that with all its distinctive main features, as well as more essential mechanical details, which during the 32 years that have elapsed since, and among the thousands of steam hammers that are the direct offspring of this original design which are doing good service to the world, these distinctive features and mechanical details remain unchanged. M. Schneider speaks of his visiting my works near Manchester, in company with his engineer, M. Burdon (about the year 1840, as I am at present led to believe), and on that occasion discussing with me some notions he then had of a steam hammer, and of comparing them with the designs for my steam hammer, which were on that occasion shown to him. The fact is, I never saw, spoke to, or corresponded with M. Schneider in my life. The visit to my works, to which he refers, was made by him and his engineer while I was absent on a journey, and the designs for my steam hammer were, as an act of civility, shown to him by my financial partner, Mr. Gaskell, who gave him, it would appear, the fullest opportunity to study them, as was often previously done in the case of visits to my works from intelligent strangers. In 1842 I made my first visit to France, having been commissioned by the French Minister of Marine to inspect and report on the mechanical department of the royal dockyards of that country. It was while on that journey, and in entire ignorance at that time that M. Schneider had visited my works, that I called, in passing from the south of France to Paris, at the Creusot Works. M. Schneider happened to be absent, but I was informed that his engineer, M. Burdon, was there. I accordingly introduced myself to him. On observing a fine specimen of forge-work lying in the yard, I remarked the excellence of its execution to M. Burdon, whereupon he, in the most frank and ready manner, said, 'That forging was executed by your steam hammer;' and on asking him how he got to know of my steam hammer, he told me, with equal frankness, the circumstance of his visit to my works during my absence, and of the civility he met with from my partner, Mr. Gaskell, who had laid before

him the designs of my steam hammer, and that on his return to Creusot he had set to work and made one. He then took me to the forge-shop, and there stood my own thumping child before me, with all the distinctive features of the parent indelibly stamped on it."—*Mechanics' Magazine.*

Rock Island R. (and Wagon) Bridge. — The bridge building by the Baltimore Bridge Co. is an immense affair. There are two spans, 260 ft. each between centres ; 3 spans, 221 ft. long between centres ; 1 draw, 366 ft. long. The bridge is estimated to carry a load of 5,000 lbs. per ft., for the crossing of teams. The bridge has 2 floors, the bottom one for the crossing of teams. The upper one, for the railway track, is 16 ft. above the former. The iron used in this portion will weigh over 4,000,000 lbs., while the whole structure will weigh over 6,000,000 lbs. It will have 2 sidewalks outside the trusses, each 5½ ft. wide. The trusses are to be 33½ ft. high, and 19½ ft. apart. The draw will be a remarkable feature in this bridge. It will be the heaviest in the world, weighing over 1,360,000 lbs., and will be moved by machinery driven by steam. The bridge, designed by C. Shaler Smith, President of the Baltimore Bridge Company, is to be entirely of iron. Two other spans of 100 and 160 ft. will complete the structure. These will have but one floor, and are intended to serve only as approaches for the railway. Total length of the bridge when completed will be 1,809 ft.

The Chicago River.—Chicago is already jubilant over the flow of its river, and the diminished force of smells which gave the place a reputation second only to that of the ancient city of Cologne. On the 15th of July the last obstacle was removed separating the waters of the Chicago river from a canal destined to carry them to the Illinois river, and a steady but slow current at once set in from Lake Michigan. With the influx of pure water the character of the south branch of the Chicago river at once changed, and though, receiving as it does much of the sewage and refuse of a great city, it is never likely to become a stream noted for its purity, yet a most marked improvement is already manifested. The enterprise of deepening the canal, inaugurated to improve, if possible, the sanitary condition of Chicago, has been a costly experiment, and one that it would have been foolish to attempt without a certainty of good results.

The Legislature of Illinois, in 1865, authorized the city authorities, with the consent of the Canal Trustees, to borrow a sum not exceeding $2,500-000 to be expended upon the work, and enacted that this outlay should constitute a lien upon the revenues of the canal after the payment of its registered debt. At first the scheme was strongly opposed, and work was not commenced until the winter of 1866. The work consisted in deepening the canal between the first two locks, situated respectively at Bridgeport and Lockport, 26 miles apart, from 8 to 10 ft., making the bottom of the canal 6 ft. below low-water mark on Lake Michigan. The canal, west of Lockport, has a declination of $\frac{1}{10}$th of a mile. For the first 16 sections the width of the canal bottom is 44 ft.; from this latter point to section 44 the width is 40 ft. Some idea may be thus formed of the magnitude of the work, the total cost of which, including interest on the bonds, is estimated at over $3,725,000.

Large as has been the sum expended, and great as must be the future expense of the work, there will be no dissatisfaction expressed should it prove successful in purifying the Chicago river. At this writing, though sufficient time has not yet elapsed to fully test the merits of the work, yet the indications are most hopeful. The only doubts which remain are regarding the power of the current formed to keep the river clear, and the possibility that strong winds from the south may at any time drive the water back with a force greater than its flow. Even should this occur, however, which is by no means certain, the condition of the river must be greatly improved by the current acting with favorable winds. It is said that one effect of the work has been to lower the water in the North Branch of the Chicago river, and threaten injury to navigation in that part of the city. It is true that the water has been lowered 2 or 3 in., but there appears no reason why the settling should continue sufficiently to interfere with the passage of boats. The deepening of the canal has had little or no effect in cleansing the North Branch, and some other of the various schemes proposed will doubtless be attempted to secure the end.

The importance of the great work just completed can scarcely be over-estimated. Not only was the condition of the river a standing offence, but a nuisance seriously affecting the health of the city. If the effort to improve the condition of the river prove unsuccessful, there will have been an immense waste of labor and money, and the enterprise will be looked upon only as a blunder; if, on the other hand, it prove even moderately successful, it will be a source of universal gratification, and no tax will be more cheerfully paid than that upon the bonds issued for the work, amounting annually to nearly $330,000.—*The American Builder.*

The Atchinson Bridge is a foregone conclusion, soon to be realized. At a meeting at Boston, on the 24th, the representatives of the C. & S. W., C. B. & Q., H. & St. Jo., Central Branch U. P. and A. T. & S Fe roads agreed to construct a bridge jointly, and arranged to commence work immediately.

ORDNANCE AND NAVAL NOTES.

Henry's Dummy Cartridge.—The introduction of breech-loading rifles into our service has materially altered the drill, one portion of which is the taking of an imaginary cartridge from an imaginary pouch, and placing it, in imagination, in the chamber of the weapon. The great fault of leaving so much to imagination is, that when the cartridge comes to be actually used, the regular soldier or the volunteer, as the case may be, is awkward at his practice. It is notorious that at the Brighton review a number of cases occurred in which the cartridge became jammed in the breech of the piece. To obviate these accidents, and to familiarize the soldier with the handling of a cartridge, Mr. Henry, the gunmaker, whose barrel has been wedded to the Martini breech-piece, has invented a dummy cartridge, the adoption of which into the service will compass the above objects. It consists of a brass cartridge shell, about ½ in. long, with the base attached, and into which is fitted a wooden plug turned down to the size of the bore, and representing the remainder of the cartridge with the conical bullet projecting. The bottom of the dummy car-

tridge is perforated with a $\frac{1}{4}$ in. hole, into which a plug of india-rubber is fitted. In practising with this cartridge the striker of the gun acts on this buffer plug, and receives no injury whatever, whilst the plug itself is very enduring, one having been used in a rifle some 2,000 times but with little injury. Five or ten of these dummies served out to each man would greatly facilitate his drill, and would prevent clumsiness in practice either with ball or blank cartridge. The dummy cartridge is being introduced by Mr. E. H. Newby, of King William Street, City.

Gunpowder.—The Committee on Explosive Substances have just issued a progress report up to the 1st January, 1871. Their experiments have been carried on principally at Woolwich, and the present return gives some interesting details relative to the much-vexed question of gunpowder. Thus with reference to the utilization of our large store of L.G. powder, the Committee remark that there need be no hesitation in interchanging L.G. for R.L.G. on the ground of danger to the gun, although on the whole the latter powder gives somewhat better results. A series of experiments appear to have been carried out in order to determine the battering charges of pebble powder for all the heavy M.L.R. guns, and the results show a considerable increase in the muzzle velocity with all the guns, accompanied by a reduction of maximum pressure as compared with R.L.G. With reference to the effects as regards pressure due to a gun being rifled, the Committee's experiments have effectually disposed of the theoretical dogmas of some philosophers. It has been shown that rifling *per se* has no appreciable effect, provided the projectile or cylinder be of the same weight in both cases. The results appear to indicate that there is no important difference, in either velocity or pressure, between a gun in its rifled and in its smooth-bore state.

German Torpedoes.—During the war the strictest secrecy was observed respecting the torpedoes with which the German coasts were protected, but now further information with respect to them has been laid before the public. Electrical torpedoes and those exploding by concussion were both employed. The latter were charged with 75 lbs. of powder, and sunk to a depth of about 3 ft. below the surface of the water. Those exploded from the shore by means of electricity were loaded with 2 centners of dualine, a charge which is equal in force to 10 centners of powder. They were sunk at a depth of about 8 ft. The torpedoes which the "Grille" endeavored to place under the keels of the enemy's vessels were not a new invention, but the old offensive concussion torpedoes, 14 in. in diameter and 2 ft. in length, which did not prove very effective. At Pillou torpedoes charged with 4 centners of powder were improvised. A company for laying and exploding these engines of war was formed at Kiel. In sinking and taking them up 3 accidents occurred, and 14 lives were lost.

Ships' Life-boats.—At the annual general meeting of the Society of Arts, held on the 28th ult., the report was read, which intimated that 44 models and 6 drawings were submitted "in competition for the medal, but inasmuch as one competitor sent in 19 models, the number of competitors was reduced to that extent." After a careful consideration of the models and drawings, the committee, which consisted of Lord H. G. Lennox, M. P., Chairman of Council; Vice-Admiral Sir Edward Belcher; Right Hon. G. J. Goschen, M. P.; Admiral E. Ommanney, C. B.; E. J. Reed, C. B.; Admiral Ryder, etc., were of opinion that none of them sufficiently fulfilled the requirements laid down, or had sufficient merit, either of novelty or otherwise, to justify the award of a medal. The Committee, however, expressed to the Council their disappointment that the models and plans sent in did not sufficiently meet the object which the Society had in view, viz., to get a boat which would do the work at present required by a coaster or ordinary merchant ship, having the additional advantages of a life-boat, with little or no increase of cost. The Committee were of opinion that the subject was too important to be dropped. Accordingly the Council issued a notice for a fresh competition, and 10 communications have been received, which will be submitted to the consideration of the Committee.

NEW BOOKS.

The Federal Government, its Officers and their Duties. By Ransom H. Gillett. New York: Woolworth, Ainsworth & Co.

The author has had a long experience in the courts, besides twenty years of Congressional life.

His book, as he explains in the preface, "is not designed to give minute information to all who hold public office. Its object is to enable the rising generation to understand the structure of our Government, what officers are employed in its practical operation, and their general duties. Such knowledge will be highly useful to all, and especially to the American citizen, when giving direction to public affairs."

The mechanical execution of the book is excellent.

The Road Master's Assistant and Section Master's Guide. By Wm. S. Huntington. Chicago: A. M. Kellog. For sale by Van Nostrand.

The author of this little Guide is a railroad builder of many years' experience; a glance at its pages would be sufficient evidence of this, even if we were not assured of the fact from independent sources.

Everything here is regarded from the standpoint of the practical road builder. Under each section the writer sets forth the existing condition of things, whether of material or workmanship, and then follows with concise suggestions for improvement.

The book is divided into 13 chapters, whose titles are:

Track-laying. Laying the rails. About spikes. Cattle-guards. Culverts and turnouts. Ballasting track. Track repairs. Drawing spikes. Repairing switches, etc. Removing ties, snow, and ice. A word to superintendents and road-masters. On fire and water as enemies: also, on preserving fences. On railroad accidents.

As the reputation and life of a railroad depend on the work thus referred to being well done, and as the amount of this work to be done is being enormously increased every year, we trust this little book will be widely read.

THEORY OF GUNNERY. By P. ANSTRUTHER, Maj.-Gen. London: E. & F. N. Spon. For sale by Van Nostrand.

This is a pamphlet containing an exposition of the author's views respecting the methods of computation for range of projectiles. The author especially desires that his views shall be tested by the War Department, and offers the present paper to the Institution of Civil Engineers (English).

POWER IN MOTION. By JAMES ARMOUR, C. E. London: Lockwood & Co. For sale by Van Nostrand.

This is a thoroughly practical treatise, and devoted to the applications of the ordinary principles of mechanics, to the use of wheel gearing, belts, wire rope, and the simple elements of machinery in general.

The rules for belting are well given and fully illustrated. The elucidation of the principles of revolution of force and motion is adapted to the comprehension of those not skilled in the advanced methods of analysis.

THE GAS CONSUMER'S GUIDE: A Book of Instruction on the Proper Management and Economical Use of Gas. With a full description of Gas Meters, and Directions for Ascertaining the Consumption by Meter. On Ventilation, etc., Alexander Moore, Boston; S. C. Griggs & Co., Chicago. For Sale by Van Nostrand.

There is, perhaps, no single item of expense connected with living and working, which is paid with as much unwillingness as are gas bills. The majority of people are unable to tell whether or not the amount claimed from them is justly due, and with a universal lack of faith in human nature, conclude that they are overcharged, and, it must be admitted, that not a few of the gas companies give to their customers grounds for believing in the doctrine of total depravity, at least as regards corporations. People pay too much money for gas, but not always from any fault of the producers. There is an economical and an extravagant way of burning gas, but the knowledge of these ways is confined to the few. It includes an acquaintance with the different kinds of burners and their relative merits, and of the best means of regulating the supply by the meters commonly in use.

To give this needed knowledge is the object of the little book of which the title is given above, and it appears well adapted to the purpose. As an index to the inclusiveness of its contents, it may be stated, that, besides giving a brief history of the means of artificial light, it explains the manner of manufacturing gas, describes the varieties and estimates of the different fittings, brackets, burners, flames, reflectors, etc., and gives at length, what constitutes one of its greatest merits, the means of reading meters and managing gas in the various uses to which it is put. The work concludes with a short treatise on ventilation, which contains many valuable suggestions, and we have no hesitation in commending the book, as one which will amply repay any consumer of gas for its purchase and the trouble of reading.—*American Builder.*

A FEW WORDS ABOUT GASES. By C. C. GRINDY. London: Simpkin, Marshall & Co., 1871.

This little book of 58 pages, which is supplied to working men at 6d. a copy, is written "for those who have little time or money to spend in the acquisition of information not immediately connected with their occupations." A great many important truths are to be learnt in the study of the properties of these powerful agents, which are too often neglected, simply because they are invisible. And not a few of these lessons Mr. Grindy teaches with great clearness and accuracy. The writer well deserves encouragement.

BRIDGES' GUNNER'S POCKET-BOOK. Compiled by CAPTAIN T. W. BRIDGES, H. P. Royal Artillery. London: E. and F. N. Spon, 1871. For sale by Van Nostrand.

Were we in want of an excuse for noticing this little military manual, we might find it in the fact that the Volunteer Artillery Corps are largely recruited from the various branches of the engineering profession. Captain Bridges has compiled this pocket book, which contains various tables, formulæ, abridged gun-drills, ranges, and miscellaneous artillery memoranda, from sundry manuals of a similar kind, but of a larger size; his object being to produce a miniature work which could be carried in a uniform pouch. As a rule, we object to the practice of trusting entirely to a formula-book in the pocket, instead of data and principles clearly arranged in the head. Those who rely too implicitly on such aids are sure to find themselves sooner or later without them in some emergency, and in consequence, as much at a loss as Mr. Bouncer, in "Verdant Green," at his examination, when his reference cards would not work. At the same time artilleymen are expected to remember such an enormous quantity of petty facts, weights, dimensions, ranges, elevations, etc., that in their case there is really some excuse for a memorandum-bock like the one before us. But we think that Captain Bridges might have arranged the contents better, and classified them with advantage under the respective heads of Field and Garrison Artillery. As it is, we find the "Weight of Forage," and "Marks on cast-iron Ordnance," in juxtaposition; while the composition of light and smoke balls, and the formulæ for piles of shot and shell, are introduced inio the middle of memorada useful chiefly to troops on the march. Some notes on judging distances and finding ranges in the field would have been a useful addition; the omission of all reference to the Moncrieff gun-carriage is a noticeable defect. In fact, possibly owing to its being the work of an officer on half-pay, the information generally seems scarcely up to the present time. We trust at least that the Artillery carbines, patterns 1853 and 1861, the only ones described, are quite out of date.

THE METALS USED IN CONSTRUCTION: IRON, STEEL, BESSEMER METAL, ETC. By FRANCIS HERBERT JOYNSON. Illustrated. W. P. Nimmo, Edinburgh. For sale by Van Nostrand.

To all engineers and mechanics, to all artists and artisans in metals, this little work on the metals used in construction, the greater part of which is devoted to iron and steel, will be interesting and useful. There can be no question that perfect knowledge of the material wrought is necessary for every worker. In the hand-book before us the chapters are severally entitled: cast-iron, malleable, or wrought-iron, steel, copper, lead, zinc, tin, galvanized iron, brass, alloys, and miscellaneous notes connected with the manipulation of metals. As a book of reference for

youths entering the workshop it is invaluable, and all searchers after knowledge will find in it much that is practically good, and could only be obtained from a man who had gained his experience practically.

Triumphs of Invention and Discovery in Art and Science. By J. Hamilton Fyfe. With illustrations. London: T. Nelson & Sons, 1871.

This is one of those "Books for Boys," which the publishers have distinguished themselves by bringing out, in form beautiful, yet inexpensive; and in matter, sound and healthy, while attractive. Mr. Fyfe's plan is good, and admirably carried out. In his 13 chapters, descriptive of so many branches of art or industry, the leading incidents in the lives of the chief inventors and discoverers are related, while a clear summary is given of the present condition of each department. The account of the art of Printing relates the feats of Gutenburg and Caxton; and that of the "Steam Engine" the inventions of Lord Worcester and James Watt. "Railways" are associated with a history of the Stephensons; and the "manufacture of cotton," with the improvements made by Kay, Hargreaves, Arkwright, Crompton, Cartwright, and Sir R. Peel. The "Lighthouses" described are those of Eddystone, Bell Rock, and Skerryvore; and the "Iron Manufacture" is traced in the Life of Henry Cort. "The Ocean Steamers" of the present day are traced from the inventions of Symington, Fulton, and Bell; and the chapter on the Electric Telegraph gives a very clear account of the experiments of Cook and Wheatstone. Under "Silk Manufacture" is a narrative of the lives of Tombe, Lee, and Jacquard. And under "Potter's Art," a history of Della Robbia, Palissy, and Wedgwood. Three other chapters relate to the Miner's Lamp and Davy's Life; to the Postal System, and Sir Rowland Hill; and to the Overland Route, from the adventures of Lieutenant Waghorn to the final success of the Suez Canal. This book has very substantial merits. It does not deal in the merely romantic incidents of invention, but clearly and accurately presents the leading facts in the history of each department in a manner which becomes doubly interesting and instructive, for our ingenious youth, by being interwoven with the life-history of many noble mechanics of olden times.

MISCELLANEOUS.

The American Institute of Mining Engineers completed its organization at its first regular meeting on 16th, 17th, and 18th of May.

The names of its officers and enrolled members afford promise of a high degree of usefulness for the future.

The officers are as follows:

President, David Thomas, Catasaqua, Pa.

Vice-Presidents, R. W. Raymond, New York, N. Y.; E. B. Coxe, Drifton, Pa.; W. R. Symons, Pottsville, Pa.; W. P. Blake, New Haven, Conn.; J. F. Blandy, Philadelphia, Pa.; J. H. Swoyer, Wilkesbarre, Pa.

Managers, R. P. Rothwell, Wilkesbarre, Pa.; T. S. McNair, Hazleton, Pa.; G. W. Maynard, Troy, N. Y.; Raphael Pumpelly, Cambridge, Mass.; Thos. Petherick, Scranton, Pa.; T. M. Williams, Wilkesbarre, Pa.; Thomas Eagleston, Jr., New York, N. Y.; E. Gaujot, Pottsville, Pa.; Fred Prime, Jr., Easton, Pa.

Secretary, Martin Coryer, Wilkesbarre, Pa.

Treasurer, J. Pryor, Williamson, Wilkesbarre, Pa.

The Production of Bright or Lustrous Colors on Metals.—The active chemist, C. Puscher, of Nuremberg, proposes a new method of coloring metals which can be executed quickly and cheaply. He produces on these surfaces a coating of metallic sulphides analogous to those found in nature, as for example, sulphide of lead. These very stable sulphur combinations, as is well known, are not affected by ordinary agents. According to Puscher's method, in 5 minutes there may be imparted to thousands of brass articles a color varying from a beautiful gold to a copper red, then carmine red, then dark, then light aniline blue, to a blue white, like sulphide of lead, and at last a reddish white, according to the length of time they remain in the solution used. The colors possess the most beautiful lustre, and, if the articles to be colored have been previously thoroughly cleansed by means of acids and alkalies, they adhere so firmly that they may be operated upon by the polishing steel. To prepare the solution, dissolve 1½ oz. of hyposulphite of soda in 1 lb. of water, and add 1½ oz. acetate of lead dissolved in ½ lb. of water. When this clear solution is heated to 190 deg. to 210 deg. Fahr., it decomposes slowly and precipitates sulphide of lead in brown flocks. If metal is now present, a part of the sulphide of lead is deposited thereon, and according to the thickness of the deposited sulphide of lead the above-mentioned beautiful lustre colors are produced. To produce an even coloring, the articles to be colored must be evenly heated. Iron treated with this solution takes a steel-blue color; zinc, a brown color; in the case of copper objects, the first gold color does not appear; lead and zinc are entirely indifferent. If instead of the acetate of lead, an equal weight of sulphuric acid is added to the hyposulphite of soda and the process carried on as before, the brass is covered with a very beautiful red, which is followed by a green, which is not in the first-mentioned scale of colors, and changes finally to a splendid brown with green and red iris-glitter; this last is a very durable coating, and may find special attention in manufactures. Very beautiful marblized designs can be produced by using a lead solution thickened with gum-tragacanth on brass which has been heated to 210 deg. Fahr., and is afterward treated by the usual solution sulphide of lead. The solution may be used several times, and is not liable to spontaneous change.—*Technologist.*

The March number of the "Journal des Savants" contains the first portion of a very interesting article on flying machines (written in the form of a review of Marey's "Flight of Birds"), from the pen of M. J. Bertrand, of the French Institute. He combats the notion of applying the well-known principles of the mechanical theory of heat to the explanation of the flight of a bird, and points out that no trustworthy observers have as yet "taken the precaution of weighing a carrier pigeon at the beginning and end of its journey," and no one has yet answered the question, "What is the number of grammes of carbon representing the combustion accomplished by the respiration of the

bird during its journey?" The author takes the case of the swallow, the weight of which he puts at 15 grammes, and which is capable of maintaining a velocity of 15 metres per second for more than an hour. According to Navier the work developed is then 0.015 (kilo.) $\times$ 390 $\times$ 3,600 = 21,260 kilogrammetres, or 50 calories, that is to say, about equal to the heat produced by the combustion of 8 grammes of *pure* carbon. It is obvious that the entire body of the bird would be totally insufficient to furnish this amount. Being entirely free from mathematical or geometrical technicalities, the article is a very readable one.

FALLACIES OF SEASONING LUMBER.—A letter from Mr. H. G. Buckley, of Chicago, has been published, boldly attacking the old system of seasoning lumber in the open air or in kilns, as inefficient and contrary to sound reason. He gives a few practical tests to show the great advantages of the use of dry steam, as follows:

I was furnished by the Rogers Locomotive Manufacturing Company, at Paterson, N. J., with a sample of their best air-dried lumber to see if I could shrink it in dry steam. As strange as it may appear, it shrank $\frac{7}{16}$ in. to the foot in 2 days as a part of 30,000 ft. of lumber in the same room. A sample of black walnut timber from the car shops of the Hudson River Railroad shrank $\frac{5}{16}$ in. to the foot in 1 day. Some staves from a pail and tub factory that had been dried both in the air and in a hot air kiln shrank more than an inch to a pail in 1 day; and entirely green staves were equally well shrunk and dried in the same room and in the same length of time. Some gunstocks at the United States Armory, at Springfield, were more thoroughly shrunk in $2\frac{1}{2}$ days in dry steam, than others that had been dried in the air under cover for 8 years. Those sticks that were prepared from the green, in $2\frac{1}{2}$ days could be selected in the dark, from the 8 years air-dried, by their superior finish. Some timber at Pittsburg, known to have been air-dried for more than 60 years, and used for building gun carriages, was tested by baking, with some of the same size that had been prepared from the green in 48 hours in dry steam, and to the surprise of many, the 60 years air-dried wood shrank nearly double that of the steam-dried. Thousands of such cases can be furnished to those who are sceptical, or new tests can be made for their especial benefit. One person who was sceptical dried a piece of lumber 3 years in a yard and 1 whole year in a hot-air kiln, and yet the dry steam shrank it $\frac{3}{16}$ in. to the foot, and diminished its weight.

But the drying of lumber has very little importance in comparison with its being seasoned and shrunk. Six green gun-stocks, as a part of 9,000 in the same inclosure (16 by 20 ft.), at the Springfield Armory, shrank in weight the first day, 12 lbs. 3 oz.; the second day, 5 lbs. 5 oz.; the third day, 2 lbs. 13 oz. The same stocks shrank in size, the first day, $\frac{3}{64}$ in.; the second day, $\frac{9}{64}$ in.; the third day, none; thus showing that the shrinking in size stops before the timber is quite dry. There is, therefore, no advantage in drying timber after the shrinking in size stops, under a seasoning heat of dry steam.

One of the great advantages of seasoning and shrinking of lumber by dry steam is, that the lumber can never afterwards be exposed to a higher degree of heat or a more thoroughly shrinking atmosphere, unless it is actually burned to charcoal. Another advantage is, that a day in dry steam has produced better shrinkage, on an average, than a year in the air. Practical men can readily sum up the interest on capital, storage, checks, splits, warps and decay, and see if that do not amount to more than $1 per 1,000 ft., which is about the average cost of thoroughly seasoning, shrinking, and drying of lumber by dry steam.

THE NAVIGABLE WATERS OF ILLINOIS.—Few have any adequate idea of the extent of the navigable waters in and around Illinois. We estimate that the steamboat routes of the State are $\frac{1}{4}$ as long as the railroad lines, and these navigable waters have had much to do with the prospects and rapid growth of the State.

There are in and on the boundaries of Illinois the following routes of navigable streams on which steamboats run:

	MILES.
Mississippi River, Cairo to Dunleith........	678
Ohio River, Cairo to mouth of Wabash......	118
Illinois River, mouth to La Salle...........	324
Total...........................	1,120

Besides, the Wabash, on the southeast boundary, is navigable for about 180 miles of its crooked course, and there is about 70 miles of the coast of Lake Michigan on our northeast border. There are, or have been, steamboats on the Fox and Rock rivers, though they can hardly be called navigable, and these steamers have run somewhere on their upper courses, above many dams, which cut them off from their mouths. The Kaskaskia, also, we believe, has been navigated by steamboats, and the raging canal bears canal boats from Bridgeport to La Salle, 96 miles. The plans for the improvement of the Kankakee and Illinois rivers, if carried out, will add about 100 miles to the sum given above.

BORNEO COMMERCE.—The demand that sprang up last year for gutta-percha, and which has gone on steadily increasing, has infused a great activity into the whole country, and so long as the present high rates are given, the native dealers and collectors will continue to bring it to market. The difficulty of obtaining it is now much greater than in former years, as, owing to the reckless way in which trees are felled and the gutta-percha extracted, they have almost entirely disappeared from the neighborhood of the rivers, and collectors have now to penetrate much further into the forests in search of the trees than was formerly the case. This is one of the reasons that have caused the price to rise so high in so short a time, but probably the chief reason is the competition which thus has lately arisen. Formerly, one firm was the large purchaser, but now agents for Singapore firms have entered the Sarawak market. The price of gutta-percha, which, in the early part of 1869 was from $25 to $$25\frac{1}{2}$ the picul of 133 lbs., has more than doubled, having gradually risen from $65 to $115 the picul. The Cinnabar mines, worked by the Borneo Company, may now be considered fairly started. Retorts have been erected during the past year, and a fair quantity of quicksilver has been obtained. The great difficulty of transport, however, enhances the cost of working very considerably. The antimony mines are yielding good ore, in fair quantities.

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THE MONT CENIS TUNNEL.

(*Continued from page* 229.)

GENERAL DESCRIPTION OF THE WORKSHOPS AND WATER SUPPLY.

The ground lying between the torrent of Rochemolles and the village of that name, being on a slight and regular incline, was chosen as the site for the principal workshops, including the repair shops, the buildings for the air compressors, the dwelling-houses for the engineer, clerks, workmen, etc. In order to secure good communication between these large workshops and the head of the tunnel, a road was built along the side of the Rochemolles torrent 6,400 ft. in length. In front of the head of the tunnel, on the top of an embankment, mostly composed of rock excavated from the workings, smaller shops were established for those purposes which more closely appertained to the actual work of excavation, such as sheds for mortar mills, carpenters' shops, and repair shops, for making small alterations, and for doing general jobs to the boring machines, smiths' forges, etc.

At the commencement of the excavation, brick-yards were also established; but they were afterwards abandoned, the bricks being provided by contract, and transported from Oulx, where they were manufactured.

On the road leading to these secondary shops, and at some distance from any habitation, was located the chief powder magazine, which contained usually more than 25,000 lbs. of powder, and from which, for the sake of safety, the necessary supplies for 2 or 3 days were periodically removed, and placed under a shed not very far from the opening of the tunnel, near the shops where the mining cartridges were fabricated. The number of workmen employed in these establishments varied a good deal, the numbers being greater or less, according to the speed with which the excavation proceeded. But the average number engaged in the shops and in the tunnel was 1,500, besides 300 more employed in getting stone from the adjacent quarries, and some 200 bricklayers employed by private contractors, so that, in all, the number of men employed in and about the works at the Italian end was about 2,000, not inclusive of those engaged upon transport.

The workmen within the tunnel worked in 8 hour shifts, and thus 3 times in every 24 hours, that is to say, at midnight, at 8 A. M., and at 4 P. M., they were changed; those, on the contrary, working at the headings had no fixed hours, only changing when each set of men had finished their task of longer or shorter duration, according to the difficulties encountered; the workmen in the shop made on the average 10 hours' work daily.

The water used for driving the different machines was brought from the torrent of Meleget, near the village of Les Armand, along a fine aqueduct in cut

stone, and thence, through a system of sluices, it passed into the channel, conveying it to the shop. This channel is built in brickwork, and averages 3 ft. 11 in. in breadth, having a capacity of a cube metre per metre of length ; it is covered in some places with a brick arch, in others with stone flags ; for some distance it skirts the torrent, then turns, and follows the side of the mountains, underneath various torrents, until it crosses the Merdoune, by means of an aqueduct, after a course of nearly 2 miles. The waters of the Meleget, after heavy rain and thaws, are sometimes very muddy, and full of sticks and leaves, small roots, straw, and other debris, that would interfere with the action of the compressors first employed ; in order to prevent any serious inconvenience a large settling reservoir was made near Bardonnèche, and about $\frac{2}{3}$ of the distance from the commencement of the conduit. The water rushing into this reservoir with a great rapidity, attained by the fall of the channel, spread itself, losing its velocity instantly, depositing at the bottom the substance of the greatest specific gravity, whilst the lighter ones, floating onwards, were stopped at the outfall of the reservoir by movable gratings.

THE VARIOUS BUILDINGS AND THEIR USES.

On entering the principal yard of the Bardonnèche road, one sees on the right hand a plain building containing the offices. Near this is the mouth of the tunnel, which is made to connect the great tunnel with the Bussoleno-Bardonnèche line. The length of this connecting tunnel is 820 ft. Opposite the offices stand the dwelling-houses of the employés, and contain a club. Behind it are the wooden store shed, washing house, and infirmary, and not far off are small gas works, and a gas holder standing within a close circular shed. These works, which now only supply gas for lighting up different parts of the yard, were at first intended to make the gas with which it was proposed to light the interior of the tunnel as the work proceeded ; but this was found to be attended with great inconvenience, for when blasts were made, the expansion of the air extinguished the gas, and the workmen very often found themselves in perfect darkness, which, besides causing confusion and loss of time, permitted the free escape of gas which further vitiated the air, impure already from the explosion of the powder, and the exhalations of the workmen.

Along the banks of the torrent of Rochemolles are the dwelling-houses of the workmen, which are protected against floods by an embankment formed with the rock excavated from the tunnel. The unmarried men had 1 room awarded to 4, the married men lived in separate houses, and each having a room. In the centre of the yard is a spacious court, round which are ranged the repair shops, the compressor buildings, and a school-house for the workmen's children, and containing the apartments of the masters and mistresses, and a provision store. Opposite this building are two large reservoirs for compressed air, the use of which will be explained hereafter.

The shops for repairing the boring tools, and other machinery, contain every necessary for the purpose, such as lathes, planing machines, drilling machines, shaping machines, etc., besides the smiths' forges and air-driven hammers. The whole of the machinery with this last exception is driven by a 12-horse power wheel. A shop thoroughly well suited for these repairs was absolutely necessary in order that the constantly recurring alterations and repairs required by the perforators, should be done without any delay. The rapid destruction of their tools was due principally to the injurious action of the quartz dust, cut away by them, but also by the violent shocks which they constantly received when at work.

Near the repair shops, and occupying one side of the court-yard, are the compressor houses. The one first completed, containing the water column compressor, is a large covered building, with large windows, and enclosing 10 of these important machines, which, however, were, after a short trial, abandoned. Nevertheless, they are worthy of description, for the first led to the idea of mechanical perforation, which has been attended with so abundant a success. As regards these compressors, we must note that the different heights hereafter mentioned, refer to a horizontal plane, which we will call the effluent level, because it contains that height at which the water stands in

the compression chamber when it is full of the air that is to receive the descending stroke of the compressing column.

If we suppose the spectator standing on this plane, opposite to the compressor buildings on the right and left, he will see before him 10 compressors, all of equal dimensions, and divided into 2 groups of 5 each; between the 2 groups are 2 motors, actuated by the compressed air, each of which works a horizontal rod, opening and closing at regular intervals the supply and exhaust valves of the compressors. We may call this the principal valve motion. Each group of compressors is independent of the other, and has its motor and principal valve motion, but by a very simple arrangement both groups may be worked together, while, if when they are at work it happens that some of them may become impaired, they may be isolated without interfering with the rest.

For the special class of work to which they were adapted these precautions were absolutely necessary, so that under any circumstances a sufficient quantity of air may be secured in order to prevent any stoppage in the boring operations. In front of each of the compressors there is placed an iron receiver with spherical ends, into which the compressed air is delivered at every stroke of the same column of water that affects the compression. These receivers are made abundantly strong. They are all placed in communication with each other by means of a pipe, so that they all operate together, if desired, but may by divided into groups of any number, as may be expedient. By this arrangement the amount of power can be regulated, and repairs effected without causing any delay. The contents of each of the receivers is 600 cubic ft., and in order to ascertain exactly the quantity of air produced or consumed, each receiver was tested by fixed quantities of water being poured in, and the heights of the corresponding levels were marked on a scale outside; in this way the graduations to 3.5 cubic ft. were fixed. At 85 ft. 3 in. above the efflux level is the great reservoir, in which the compressing columns unite. These 85 ft. 3 in. mark the height or stroke of the column of compression so soon as it begins to come into action. Inside the reservoir the columns are made with a funnel-shaped top, so as to avoid the effects of the contraction of the water in its flow, and each is provided with a cover, so that the water can be excluded, and the corresponding compressor emptied, and submitted to repairs when desired. The water is led into the reservoir by large iron mains, which lead it from the conduit 65 ft. 7 in. above. These mains are, of course, fitted with all the necessary valves, sluices, etc., for keeping the water under control. At a point still more elevated, 164 ft. above the plane of efflux, on the hill side, is the regulating reservoir, having a capacity equal to upwards of 14,000 cubic ft., built in brickwork, and roofed over, the covering being supported on pillars, and earth being placed above for a depth of 3 ft. 3 in. to protect the water from the action of frost. From this reservoir two iron pipes are taken, each communicating with one of the 2 groups of receivers before mentioned, both groups being connected to the pipe that draws water from the regulating reservoir, and the columns of water contained in these pipes for their height of 164 ft. maintain almost invariably the pressure of air on the receivers. As regards the regulating columns, the receivers are put in action by means of appropriate valves, together or separately, so that in this detail also they work together or separately, as may be desired.

It was soon found, however, that these compressors became damaged by the violent shocks the valve had to resist, when they were suddenly closed, and hence their use has been abandoned; the simple machines known as the "water-spout" compressors, were found to be more reliable, so that all the compressed air has been produced by these machines. The water-spout compressors at work in the yard are actuated by 7 water-wheels; the quantity of water used is small, only 35.317 cubic ft. per second, but it has a considerable fall of 144 ft. The wheels were placed one below the other, so that the waste canal of one forms the supply canal of the other, and thus all the fall was utilized by giving 19 ft. 8 in. of fall to each wheel. The wheels are placed in separate buildings; the 3 lower ones are arranged back to back. A description of one will suffice for all. An iron wheel, 19

ft. 8 in. in diameter and 16 ft. 4 in. wide, gives motion from the shaft on which it is mounted to 2 heavy connecting rods, actuating 2 pistons. On each side of the wheel, stand coupled together 2 large cast-iron cylinders, vertical, but turned round at right angles at the floor level so as to form horizontal cylinders in which the pistons before mentioned work slowly, their alternate motion being communicated to a water column, which, rising and falling alternately in the vertical part of the cylinders, compresses the air which is admitted into, and forced from, the cylinder by means of a set of ordinary inlet and outlet valves.

An iron staircase leads to a gallery from which the upper part of the machinery may be examined. Everything works with the utmost precision, the motion is perfectly regular and free from shock, so that these machines work constantly for years without requiring repairs. The compressed air is passed into the receivers before mentioned, by a collecting pipe communicating with all the compressors. Up to 1864 these receivers were the only reservoirs for the compressed air, but they were insufficient for the quantity required, especially when any short delay took place in maintaining the supply. It became necessary, therefore, to construct other reservoirs, and 2 wrought-iron receivers, 164 ft. long and 6 ft. 6 in. diameter, were made, and now stand under the school-house and provision store.

When these were made, the regulating reservoir became insufficient, and therefore it would have been necessary to construct a much larger one ; but this great expense was avoided by regulating the pressure in the following manner : The consumption of the compressed air, or the working of the perforators, was intermittent ; during the time of work the consumption was equal to the quantity produced, but in the time of stoppages, the air passed from the compressors into the reservoir, and increased the pressure in them ; when this reached 6 atmospheres, a safety valve in the main that carried the air along the tunnel, opened, and the air that escaped through it was carried by a tube to ventilate the farthest headings ; and this was a very necessary precaution, because, when the mines were exploded, the dense smoke caused by the combustion of the powder rendered the workings untenable. So soon as the boring machines were put into work again, the pressure of course fell, and the safety valve closed. In this manner the pressure was regulated well, and with economy.

The large main that conducted the compressed air to the extreme limits of the heading, was laid along the road, resting on brick pillars, for a length of 6,400 ft., to the opening of the tunnel. This main was exposed to all the inclemency of the climate of Bardonnèche, and to variations of temperature ranging from 15 deg. of frost to 140 deg. in the sun. But these violent extremes had no serious effect upon it, although during winter a part of the main was always covered with snow. The tube is 7.84 in. inside diameter, it is .39 in. thick, and is made in lengths of 6 to 8 ft. These were cast with special care, and the joints are made good with compressed gutta-percha.

We may now say a few words about the shops at the entrance of the tunnel. Here are located the forges for repairing and sharpening the boring tools, the blast being obtained from a fan worked by a 10-horse water wheel. There are also workshops to repair the less important damages sustained by the drills, and which saved the trouble of their being removed to the main shops already described. Here, also, is a dwelling-house for the mechanics. Further on is an observatory—a small hexagonal tower, marking the line which passes through the centre of the tunnel, in the centre of which, and standing on a strong foundation, is a theodolite. At the entrance of the yard is the clerk's house, with the offices, and provision stores, general stores, stables, etc. A long shed serves for the carpenters' shops, and wagon shelters.

The mortar mills are also here, and near them a small machine for making clay tamps for the blasts ; the clay is forced through orifices of the desired size, and is cut off into lengths with wires, and dried. A large ventilator placed over the tunnel entrance drew through a wooden conduit, fixed to the roof of the excavation, the external air replacing it as it was exhausted. This fan was driven by the same wheel that

actuated the forge fan; it moved in a horizontal plane, was 19 ft. 8 in. in diameter, and was enclosed within a covered shed.

Originally the draught was produced by heated air from an upcast shaft, and though this arrangement answered when the borings had reached no great depth, it became of course entirely inefficient as the work advanced.

THE HEAT-RESTORING GAS-FURNACE.

From "The Mining Journal."

The importance of economizing fuel in the manufacture of iron, to enable us successfully to compete with foreign countries, can scarcely be over-estimated, and, in connection with the production of the finished metal, Gorman's heat-restoring furnace and Siemens' regenerative furnace have each proved to be of enormous value. In a paper read before the Institution of Engineers in Scotland, Mr. Gorman remarked that, when it is considered that a ton of iron at the welding point contains only the amount of heat which is due to about 56 lbs. of coal, and that usually 20 times this quantity is employed, it will appear that there is much room and much need for improvement in this department. The heat-restoring gas-furnace is designed to economize fuel by restoring part of the heat which escapes in ordinary furnaces, and it so happens that the arrangements necessary for this purpose are also admirably adapted for consuming the volatile gases of coal, thereby increasing economy and preventing smoke. It has been successfully applied in manufacturing iron, re-heating for plate and bar mills, puddling, welding scrap, etc. In the shipbuilders' yard—forging and working plates, long angles, bars, etc.; it is also in use for boiler-makers, bridge builders, rivet and nail makers, and for enamelling and annealing, and has been so often erected in the neighborhood of Glasgow that only a very short description of it will be necessary. It is heated by combustible gases, which may be supplied from any suitable source, but have hitherto been supplied from the ordinary coal or slack procured in the neighborhood, and produced in apparatus attached to the furnace.

The gas used for illuminating towns, and the gases escaping from blast-furnaces may also be used effectively and economically for supplying the requisite heat, so that it is not essentially necessary that the gas should be produced in connection with this furnace. The furnace, with its gas-producer and heat-restorer, occupies about the same space, and is arranged and worked in the same way as an ordinary heating or puddling furnace, when applied to the same purpose; and, in addition to the usual damper, it has valves for regulating, admitting, or shutting off the air supplied for combustion as required. The gas producer occupies the same place as the grate room in ordinary furnaces, and only differs in being deeper, so as to allow, at all times, a thickness of over 2 ft. of fuel on the grate bars; this provision is necessary to prevent carbonic acid gas from rising amongst the combustible gases, the presence of which, even in small quantities, prevents the combustion of the volatile gases of coal, and is in all cases deleterious, and cannot be too carefully guarded against. Although the difference between the gas-producer and the fire of the common furnace appears very little, yet it is very great, and it is most important that it should be understood and properly worked, or the furnace will not heat well or give its highest results. All that is required is to keep the bars clean, taking out clinkers only, but no coke or charred coal can be avoided; fire often, and keep the fuel up level with the firing door, or higher, at all times, and not to put much on at a time.

When the gas from the coal leaves the producer, carrying with it the heat generated there, it is supplied at the bridge with air, in the proportion of about 12 times the weight of the fuel. The more heat which can be imparted to the air supplied for combustion, the less coal is required to maintain a given temperature in the furnace. The question becomes then—What is the best practical method of transferring the greatest amount of

heat from the highly-heated waste products, leaving a furnace to the air entering a furnace for combustion? The apparatus employed for this purpose is called a heat-restorer; it is based on a very elegant instrument for transferring heat, and which consists of 2 tubes, 1 placed within the other, the inlet of 1 tube adjoining the outlet of the other. The tubes are open at both ends. If hot water be poured into 1 tube and cold water in the other, the hot water will run out cold, and the cold water will leave the instrument heated very nearly to the temperature of the water which was poured in hot. The waste heat is transferred to the air for combustion by the restorer, in the same manner. The restorer is a chamber placed usually underneath the ground line, into which is placed a number of fire-clay pipes open at each end. A wall runs up at each end of the pipes, dividing the chamber into 3 compartments, 1 large in the centre, and 1 at each end of the pipes into which they open, connecting the smaller end chambers. The flame, or waste heat from the furnace, passes downwards through the centre compartment, impinging on the outside of the tubes placed therein. The air for combustion enters the end space at the bottom, passes through the pipes to the other end, rising to a higher series of tubes, and re-crossing till it arrives at the top of the chamber; the effect being an upward current of air meeting a downward current of heated gases, with only the thickness of the fire-clay tube between them; the current of air inside preventing the destruction of the tube by the high temperature outside. The only extra about this furnace, which has no counterpart in the common furnace, is the restorer, and in practice it gives no trouble. A set of restorer tubes has been worked regularly for 2 years, and when taken out for repairs, more than $\frac{1}{2}$ were fit for use again.

With a view to ascertain the relative merits of the common furnace and the Gorman furnace, several series of experiments have been made. Five piles, each 470 lbs. = 2,350 lbs. were weighed and charged into the gas-furnace; the result was a yield of 2,247 lbs. of rolled iron, being a loss of 103 lbs., or 4.38 per cent. of the iron charged. At the same time the same number of piles of equal weight were charged into an ordinary furnace; the result was 2,058 lbs. of rolled iron, being a loss of 292 lbs., or $12\frac{1}{2}$ per cent. nearly, of the iron charged, so that in the gas-furnace 1 cwt. 3 qrs. 19 lbs. less iron is used to produce a ton of rolled iron than with the ordinary furnace. These results were confirmed by subsequent trials; the returns of each are within a fraction of the above statements. A more extended series of trials was made by the Mossend Iron Company, to compare the waste of iron in the heat-restoring furnace, and that of the common furnace; 7 heats were charged into the common furnace, and 7 exactly similar heats into the gas-furnace; the result showed a saving in iron by the gas-furnace of 3 qrs. 19 lbs. per ton of iron produced, including croppings; but the saving is higher when estimated on finished iron, as of course it must be, to get a commercial result. Now, in producing 16 tons of finished iron, 20 tons of iron require to be heated, and when the loss on 20 tons charged is estimated on 16 tons finished iron in each case, the saving of the gas-furnace in the above instance is 1 cwt. 7 lbs. per ton of finished iron. The next comparative trials were made at the works of the Lancefield Forge Company. There were two gas-furnaces erected there, and from various causes they were not worked to a successful issue, and finally abandoned, to the loss of the firm, and of the inventor of the furnace. One of the furnaces did not work properly; in the other furnace, five days' trial, producing welded iron from scrap, showed 1 cwt. 1 qr. 7 lbs. less waste per ton of iron when it was welded in the gas-furnace. The next trials for comparing the common and gas-furnaces were made by Messrs. Colville & Gray, Coatbridge, who weighed the materials during a week's work of the gas-furnace and 2 common furnaces. There was a saving in this instance, in iron, $1\frac{1}{4}$ cwt. at 5s. = 6s. 3d.; and in fuel, 5s.; in all 11s. 3d. per ton of puddled iron. At this time the workmen stated that they would as soon work the gas as the common furnace. Further trials of a gas-furnace for welding scrap were made by Messrs. Gray & Wylie, Coatbridge, and they mention in their note that "the scrap used in these trials was all old scrap from a broker's yard; had we used new scrap of our own make, the waste would have been much

less. It will be observed that triping coal was used in the heats; we are in the habit of using dross, but in this instance were disappointed in getting it in ; we find dross does the work equally well, and takes very little more weight than shown."

Referring to the advantages of the new furnace, Mr. Gorman points out that the gas-furnace is more easily kept in repair, and that it will do a third more work, with about ½ the weight of dross that is required in coal with the common furnace; but the peculiar feature of the gas-furnace is the non-oxidizing quality of the flame compared with that of the common furnace. When iron is welded in the flame of the common furnace, it is more or less oxidized or burned, depending on the amount of surface exposed, and when iron is thus heated its strength and tenacity are seriously impaired, and when it is overheated in the common furnace it is simply "burned," and any means by which such a contingency can be prevented or ameliorated ought to be adopted, more particularly in forgings, on the strength and tenacity of which depends human life, and it will materially add to our economical resources, when the engineer can depend on the intrinsic quality of his material, and not be compelled to resort to mere bulk and weight for safety. Mr. Gorman further maintains that when iron has parted with the most of its impurities, it is then in the most critical condition for being oxidized or burned. While impurities are present, they, to a certain extent, by their oxidation, save the iron ; but, afterwards, each time it is heated in the common furnace it is exposed to free oxygen, and consequently loses its substance, strength, and tenacity, till at last it arrives at its normal state of an oxide or ironstone, and this is not a remote contingency, as a ton of scrap iron heated 6 times in the common furnace oxidizes a ton of iron to cinder.

Mr. Gorman has introduced a new form of puddling-furnace, which has undergone several modifications in accommodation to circumstances. There was no difficulty in obtaining heat, but puddling is not a mere question of heat ; and after many trials, the existing arrangement is believed to be adapted to all the conditions necessary in the puddling process. Many very favorable results have been obtained from trials of former modifications. The flame travels all round the furnace, and escapes at a port adjoining that where it enters the furnace ; thence it passes under an oven or retort in which the coal is placed, so that the waste heat is caused to coke the coal previous to passing to the restorer, thereby producing a hotter and purer gas, and at less expense of coal. By this means the flame is also cooled a little, so that it is not so severe on the tubes as it was found to be when passing direct from the puddling chamber of the furnace. It will be observed that the tubes are placed behind the furnace in this instance. This was found necessary in order to allow the furnace to cool quicker for fettling, and to keep the puddling stance cooler. The method of returning the flame in the furnace was modified from an arrangement in which the flame was caused to circulate in vertical planes, the flame passing out of the back of the furnace. It is named the "whirl flame" furnace, from the action of the flame. It is worked with dross; a saving in fuel of 10 cwt. per ton of puddled iron, and a saving in the yield of iron of at least a ½ cwt. to the ton, have been obtained at the Clydesdale Iron Works, Holytown, where 12 puddling furnaces are working on this plan. The method of returning the flame now adopted in the puddling furnace has been found to heat a third more iron with 15 cwt. dross per day, than was done formerly by a common furnace with 28 cwt. splint coal ; the repairs are reduced by one-half. The puddling furnace is now being rapidly developed; and there is no doubt, he thinks, as to its realizing as large an economy as the heating furnace, the effect of which will reduce the price of making malleable iron about 20s. per ton.

In the discussion which followed the reading of the paper, it was elicited that Gorman's furnace is simpler in arrangement than Siemens', which is on the same principle as Stirling's regenerator. In reply to Mr. Kay, it was stated by Mr. Gorman that they preferred to use the blast where it could be got, and that there was no chance of dangerous explosion ; he had seen some furnaces explode, but not after they had got into use, and only a few bricks had been displaced. He was engaged in applying the principle to smelting, and also to smiths' and founders'

furnaces. The President (Mr. David Rowan) remarked that there were other competing furnaces, such as Siemens' and others, all brought forward as saving iron and coal, but this furnace seemed to have another advantage—to be able to use triping and dross instead of splint coal; he had no doubt that this system of furnace might come into use for other purposes. Mr. Gorman had patented improvements in furnaces in 1852, and shown how gas was produced and used in furnaces in 1858, before Siemens brought out his gas-furnace. He intended to put up furnaces to work with half the coal used by Siemens' furnace, but the consumption of fuel by those furnaces was kept in the background. But, taking such data as he had been able to get, the fuel was 6.6 cwt. per ton of iron heated; in his own case, it was as low as 3.4 or 3.5 cwt. The economy from Mr. Siemens' furnace should be greater than what is obtained, and he accounted for the defect partly from it requiring to be of the same shape at the inlet and the outlet, to allow of the reversing of the currents—conditions which would cause great waste of fuel in other furnaces, and would also act in the same way against the Siemens furnace. The low temperature at which the gases escape from the Siemens furnace is referred to as an evidence that the heat is all used, but, as stated formerly, the heat contained in a ton of iron at the welding point amounts only to what can be obtained from about 56 lbs. of carbon, and as fully 12 times that amount is used in his furnace, $\frac{11}{12}$ of the heat should escape. The largeness of the structures would account for part of the loss of heat, but not sufficiently for the low temperature obtained, but the great loss of heat may be referred to another cause. It is a well-known fact that when the volatile gases from coal are heated above redness they are decomposed and their carbon deposited; now, it follows that when such gases are passed through the regenerator of Siemens' furnace the carbon will be deposited on the hot bricks, and will not reach the working chamber of the furnace, which is thus deprived of the heat from $\frac{2}{5}$ of the most valuable part of the coal. When the currents are reversed, this carbon will necessarily unite with the escaping flame to produce carbonic oxide gas, which is colorless, and lowers its temperature 60 per cent., and at the same time carries a great part of the fuel up the chimney, thus having an appearance of great economy, while there is actually great waste going on. Parties conversant with those subjects will understand this at once, but, as a practical proof, he might mention that while the hand may be held in the gases escaping from the Siemens furnace, those from the heat-restoring furnace will melt brass, even while working to a much higher economy than he had heard recorded of the Siemens furnace.

ON THE GASEOUS AND LIQUID STATES OF MATTER.

From "Nature."

A discourse was delivered on Friday evening, June 2d, at the Royal Institution in Albemarle street, by Dr. Andrews, on the "Gaseous and Liquid States of Matter," from which we make the following extracts:—"The liquid state of matter forms a link between the solid and gaseous states. This link is, however, often suppressed, and the solid passes directly into gaseous or vaporous form. In the intense cold of an arctic winter, hard ice will gradually change into transparent vapor without previously assuming the form of water. Carbonic acid snow passes rapidly into gas when exposed to the air, and can with difficulty be liquefied in open tubes. Its boiling point, as Faraday has shown, presents the apparent anomaly of being lower in the thermometric scale than its melting point—a statement less paradoxical than it may at first appear, if we remember that water can exist as vapor at temperatures far lower than those at which it can exist as liquid. Whether the transition be directly from solid to gaseous, or from solid to liquid and from liquid to gaseous, a marked change of physical properties occurs at each step or break, and heat is absorbed, as was proved long ago by Black, without producing elevation of temperature. Many solids and liquids will for this reason

maintain a low temperature, even when surrounded by a white hot atmosphere, and the remarkable experiment of solidifying water and even mercury on a red hot plate, finds thus an easy explanation. The term spheroidal state, when applied to water floating on a cushion of vapor over a red hot plate, is, however, apt to mislead. The water is not here in any peculiar state. It is simply water evaporating rapidly at a few degrees below its boiling point, and all its properties, even those of capillarity, are the properties of ordinary water at 96.5 deg. C. The interesting phenomena exhibited

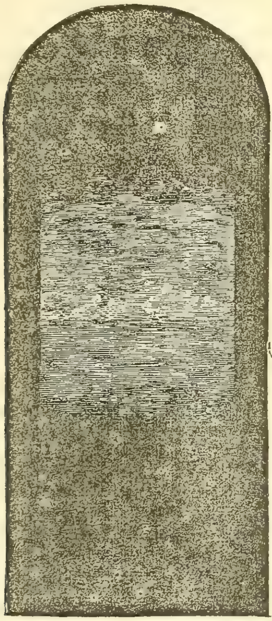


Fig. 1.—Cloud below critical point.

under these conditions are due to other causes, and not to any new or peculiar state of the liquid itself. The fine researches of Dalton upon vapors, and the memorable discovery by Faraday of the liquefaction of gases by pressure alone, finished the work which Black had begun. Our knowledge of the conditions under which matter passes abruptly from the gaseous to the liquid and from the liquid to the solid state, may now be regarded as almost complete.

"In 1822 Cagniard de la Tour made some remarkable experiments, which still bear his name, and which may be regarded as the starting point of the investigations which form the chief subject of this address. Cagniard de la Tour's first experiments were made in a small Papin's digester, constructed from the thick end of a gun barrel, into which he introduced a little alcohol and also a small quartz ball, and firmly closed the whole. On heating the gun barrel with its contents over an open fire, and observing from time to time the sound produced by the ball when the apparatus was shaken, he inferred that after a certain temperature was attained the liquid had disappeared. He afterwards succeeded in repeating the experiment in glass tubes, and arrived at

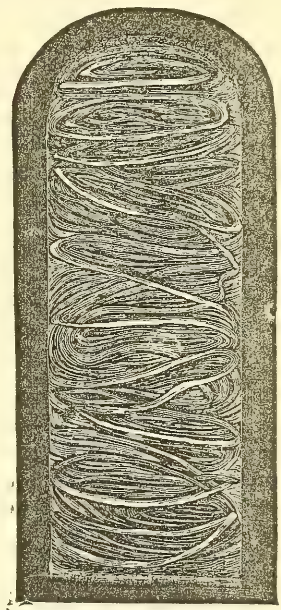


Fig. 2.—Striæ above critical point.

the following results: An hermetically sealed glass tube, containing sufficient alcohol to occupy $\frac{2}{5}$ of its capacity, was gradually heated, when the liquid was seen to dilate, and its mobility at the same time to become gradually greater. After attaining to nearly twice its original volume, the liquid completely disappeared, and was converted into a vapor so transparent that the tube appeared to be quite empty. On allowing the tube to cool, a very thick cloud was formed, after which the liquid reappeared in its former state.

"It is singular that in this otherwise accurate description Cagniard de la Tour

should have overlooked the most remarkable phenomenon of all—the moving or flickering striæ which fill the tube, when, after heating it above the *critical point*, the temperature is quickly lowered. This phenomenon was first observed by the lecturer in 1863, when experimenting with carbonic acid, and may be admirably seen by heating such liquids as ether or sulphurous acid in hermetically sealed tubes, of which, when cold, they occupy about $\frac{1}{3}$ of the capacity. The appearances exhibited by the ascending and descending sheets of matter of unequal density are most remarkable, but it is difficult to give an adequate description of them in words or even to delineate them.

"These striæ arise from the great changes of density which slight variations of temperature or pressure produce when liquids are heated in a confined space above the critical point already referred to; but they are not formed if the temperature and pressure are kept steady. When seen they are always a proof that the matter in the tube is homogeneous, and that we have not liquid and gas in presence of one another. They are, in short, an extraordinary development of the movements observed in ordinary liquids and gases when heated from below. The fact that at a temperature of 0.2 deg. above its critical point carbonic acid diminishes to $\frac{1}{2}$ its volume from an increase of only $\frac{1}{37}$ of the entire pressure, is sufficient to account for the marked characters they exhibit.

"If the temperature is allowed to fall a little below the critical point, the formation of cloud shows that we have now heterogeneous matter in the tube, minute drops of liquid in presence of a gas. From the midst of this cloud (as shown in Fig. 1) a faint surface of demarcation appears, constituting the boundary between liquid and gas, but at first wholly devoid of curvature. We must, however, take care not to suppose that a cloud necessarily precedes the formation of true liquid. If the pressure be sufficiently great, no cloud of any kind will form."

After describing the results obtained by the lecturer with carbonic acid under varied conditions of temperature and pressure, Dr. Andrews remarked that it would be erroneous to say that between liquid and gas there exists one intermediate state of matter, but that it is correct to say that between ordinary liquid and ordinary gas there is an infinite number of intermediate conditions of matter, establishing perfect continuity between the two states. Under great pressures the passage from the liquid to the gaseous state is effected on the application of heat without any break or breach of continuity. A solid model, constructed by Prof. J. Thomson, from the data furnished by the experiments of the lecturer, exhibited very clearly the different paths which connect the liquid and gaseous states, showing the ordinary passage by break from the liquid, as well as the continuous passage above the critical point.

After referring to the experiments of Frankland on the change produced by pressure in the spectrum of hydrogen, and to those of the same able chemist and Lockyer on the spectrum of the spark in compressed gases, Dr. Andrews described the remarkable change from a translucent to an opaque body, which occurs when bromine is heated above the critical point; and then drew attention to the general fact that when the critical point is reached, the density of the liquid and the gas becomes identical.

In order to establish the continuity of the solid and liquid states, it would be necessary in like manner, by the combined action of heat and pressure, to obtain the solid and liquid of the same density and of like physical properties. To accomplish this result would probably require pressures far beyond any which can be reached in transparent tubes, but future experiment may show that the solid and liquid can be made to approach to the required conditions.

The Select Committee on the disputed ground on the Thames Embankment met recently, the Chancellor of the Exchequer in the chair, and examined at considerable length Mr. Gore, one of the Commissioners of Woods and Forests. He stated that the lands reclaimed from the Thames in front of Whitehall Gardens to Whitehall Place not required for the Crown lessees, or for the purposes of the Embankment proper, was the absolute property of the Crown. He was cross-examined by Mr. Locke, who called upon him to prove the title of the Crown.

BOILER EXPLOSIONS.

By H. ASHTON RAMSEY.

In the early days of steam engineering, when boilers were designed to carry a pressure of only 15 lbs. of steam to the sq. in., explosions were of rare occurrence, and when they did occur, engineers invariably attributed these terrible calamities to one of two general causes: insufficiency in the strength of the boiler, or combined carelessness and ignorance on the part of the boiler attendant.

Deficiency in the strength of a boiler may be from one or more of four primary causes—inferior and defective material, indifferent workmanship, improper design, or from oxidization of the material, the latter occurring when the water used for the feed contains chemical impurities which have an affinity for the iron, or from age.

From ignorance and negligence explosions may be brought about in the following manner: (1) From permitting an excessive pressure to accumulate in the boiler, the steam being generated more rapidly than the safety-valve orifice will permit it to escape. (2) From allowing the water in the boiler to subside below the crown-sheet or flues, which being unprotected, and subjected to the intense heat of the furnace, burns, blisters, cracks, and finally gives way; or, when in this red hot state, to suddenly raise on it the water, already heated to a high temperature, which is effected by incautiously admitting feed-water, opening the throttle-valve wide, or suddenly raising the safety-valve, either of which acts, by relieving the pressure, would cause a violent ebullition of the water, which, coming in contact with the hot surfaces of the iron, would throw off steam more rapidly than it could be carried off either by the safety-valve or throttle-valve; hence an explosion is the immediate consequence, unless the boiler should possess extraordinary strength.

For many years the above-mentioned causes, seeming so clearly to exhaust the whole subject, were universally accepted by engineers. Of late years, however, since the introduction of high-pressure steam, of such an increased tension, that the word low-pressure, still applied to non-condensing engines, has become a misnomer, there have been such frequent explosions and collapses of boilers, where the newspaper statements of the attending circumstances at the time of, or just previous to, the explosion, could not be reconciled with the above views—for instance, stating that the boiler had been thoroughly constructed, the water had not been allowed to get low, and the pressure was no higher than usual, etc.—that engineers and others began to look around for other causes for boiler explosions, and many very remarkable theories were advanced to prove the causes of the "reputed fact" that boilers had exploded under the last-named condition of circumstances. Some attributed the phenomenon to the decomposition of water into its elements, whereby highly elastic gases would be evolved, which having the explosive force of gunpowder, no vessel however strong could contain it; others to some mysterious electrical agency existing among the molecules of steam, etc.

Now, I am far from being convinced that either of the last two mentioned causes ever had anything to do with the explosion of steam boilers, or that any boiler ever exploded that had been properly designed and constructed of good material, not corroded or weakened by age, or otherwise, and carefully managed by a man understanding his business; but even supposing the above theories do have some bearing on an occasional explosion, it appears to me the advancement of such theories, tending as they do to relieve both the boilermaker and the attendant from responsibility, is fraught with great danger.

Already many engineers in speaking of boiler explosions shake their heads, look very wise, and say they are attributed to some mysterious agencies not as yet thoroughly understood, and it has become quite popular to sneer at the previously established doctrines on the subject.

Recently the writer, on visiting the scene of a boiler explosion, which was doubtless caused from bad material used in the construction of the boiler, although the newspapers did not so report it, fragments were thrown several hundred feet from the previous location of the boiler.

An engineer remarking on the explosion, was heard to say "that the boiler must necessarily have been very strong to have allowed such an enormous force to accumulate in it." Now let us see how strong the boiler would have had to have been. The boiler was designed for a pair of high-pressure cylinders, and made to carry a working pressure of 75 lbs. to the sq. in., hence certainly should not have given way under a bursting pressure of 100 lbs. to the sq. in. Now, suppose the pressure was 100 lbs.—and it must be admitted that the boiler ought to have stood this pressure—what would be the effect of say a square foot of iron driven in the air by an initial force of 100 lbs. to the sq. in. $\frac{100 \times 144}{2240} = 6\frac{42}{100}$ tons to the sq. ft.? Is it at all wonderful that such a projectile should have the power to pierce through a shingle roof, kill a man standing near, or blow through the bottom of a boat, causing it to sink.

Persons passing near a boiler and looking up to the little index of the steam gauge, as it points around to the number of lbs. of pressure in the boiler, do not realize that they are in such close proximity to a pent up force, which, although very manageable as long as confined in a well-constructed boiler of good material, is liable at any time to burst forth and spread destruction around it, when the case is reversed and the boiler is weak and unfit for service. The reports of the inspecting engineers of the "Boiler Users' Associations" in England, and the Boiler Insurance Companies of this country, show how many boilers are allowed to be operated, when they have become more dangerous than so many powder magazines.

The great expense steam users have been put to in England, on account of lawsuits brought against them to recover damages for loss of life and property, caused by boiler explosions, has affected their prospects so severely that, from self-defence, they have formed themselves into associations, and appointed competent engineers to make periodical inspections of their boilers. From a recent report appearing in "Engineering," from one of these inspectors, out of a large number of explosions and collapses, extending over a long period, there was only one attributed to causes unknown; all the others could be traced directly to weakness in some part of the boiler, or carelessness on the part of the engine-man.

In these days of strong competition among boiler builders, the temptation to use indifferent material and cheap labor is very great; therefore it is all-important that steam users should have their plans and specifications for boilers prepared by competent engineers, and have the work thoroughly inspected; also to be particular in employing none but competent attendants to take charge of their boilers, and the latter should be licensed by law, those having charge of boilers on land, as well as those on the water. In some States I believe this is already required.

By giving more attention to the construction and arrangement of steam boilers, were "steam-users" to follow the course indicated, explosions would be of rare occurrence, if not entirely prevented, and the proprietors would be large gainers pecuniarily; for the additional expense necessary to the employment, in the first place, of a competent mechanical engineer, to plan and superintend the construction of the boiler, and, secondly, the difference between the wages of an incompetent and a competent engine-man to manage it, would be insignificant compared with the great loss arising from the rapid deterioration and short life of an inferiorly constructed and badly managed boiler, to say nothing of the immense losses incurred in the case of explosions, followed by lawsuits, damages, etc.

Engineers themselves should be very slow to admit excuses for these terrible calamities; for, while we can fully recognize and appreciate the fact that steam boilers, when in use, always contain within themselves elements which, uncontrolled, would form a force sufficient to rend asunder the strongest vessel that could be fabricated, still, we also are as fully aware, that by properly regulating these elements, they are perfectly harmless and subservient to our will and purposes.

Many engineers on steamboats bestow all, or the greater part of their attention to their engines, leaving the boilers to the care of the firemen. I know the plea for this is, that they are required always to be convenient to the stopping and starting gear, so as to be able to obey sudden signals from the deck. Now, it would be

comparatively an easy matter to train an unlettered fireman to stop and start an engine, who could be left at the starting gear while the engineer made examinations of the conditions of his boiler. The latter being by far the most dangerous and important part of the mechanism under his control, and requiring all his intelligence and vigilance, and should therefore receive the greater part of his attention.

Daniel B. Martin, Esq., late Engineer in Chief of the Navy, recognized the importance of paying more attention to the boilers than had been the custom when he took charge of the machinery of one of the Collins steamers, which he operated with such signal success, distancing by far all his competitors and gaining the reputation the line earned of being then the fastest vessels on the ocean. He required his senior assistants to keep the boiler-room watch, and placed the juniors in the engine-room, which no doubt had a great deal to do with his unexampled success.

NARROW GAUGE RAILWAYS.

From "Engineering."

The first great revolution in railway practice is taking its successful course, not without strenuous opposition from prejudice, conservatism, and indifference; but all these obstacles and the difficulties they create directly and indirectly, are being swept away, as the conviction gathers strength that countries now unprovided or ill supplied with railways must soon have them, and that they must be productive, and not sources of loss. There is only one means by which this result can be achieved—a reduction of gauge, an increase of gradients and curves, cheap railways—in short, proper mechanical appliances for economically working traffic, and a rigid observance of economy in construction and in management. There are very few, even of those who have carefully followed the discussions upon narrow gauge railways in these columns and elsewhere, who have any idea of the extent to which such constructive reform has now spread. The situation may be summed up thus : In India a gauge of 3 ft. 3 in. has been established, upon a scale that will bring into existence a system probably of thousands of miles. The reduced width will, in fact, become the gauge of the country. Australia, Tasmania, and New Zealand are all following the same course. Australia especially is determined upon receiving the reform and carrying it out fully. In Russia the 3 ft. 6 in. gauge is definitely accepted, and the results of its working will shortly result in the construction of an enormous *réseau* of lines from north to south, from the Baltic, penetrating into Siberia. In Egypt the same width is to be adopted. In the United States more than 2,000 miles of narrow gauge line are in actual progress, or about to be commenced. California is organizing railways on the reduced gauge in all directions; lines are being started in the unsettled territories of the West and North-west, where communications alone are required to convert uninhabited regions to wealthy agricultural or rich mining districts; in the Eastern and the Central States, where energy and capital are most alive and plentiful, narrow gauge companies and organizations—not vague schemes, but promoted by engineers and capitalists—are urging the construction of independent railways, or of feeders to the existing lines. In Canada, where progress drags along most wearily, narrow gauge railways are being built ; even for Prince Edward's Island contractors are at the present moment solicited to tender for the construction of a 3 ft. 6 in. line from Casumpec to Georgetown, a distance of 120 miles.

So gradually do even the most rapid changes and advancements take place around us, that it is difficult to comprehend that changes *are* taking place. For the past 12 months we have been living in history, the most stirring, wonderful history the civilized world has ever known yet ; we cannot realize it ; events must pass, must become contracted by the effect of distance, which gives bold outlines while it fades out details, before we can really understand what has had place. What is not palpable to the senses cannot take easily a defined position in the mind.

When railways superseded roads, and speed in travelling was quadrupled, and comfort and business facilities infinitely increased, there was produced a mighty change palpable to all, because the effects appealed to the senses ; but it is impossible, at any special time, to realize the improvements that have been made from the days of the Manchester and Liverpool Railway to the present time, without taking a standpoint from which to review, consider, and compare all the changes and developments, each of which helped forward the end.

So now, although the establishment of a 3 ft. 6 in. gauge is the greatest change that has ever been made in railways, since railways were, it attracts but little attention save from those capitalists and engineers immediately within the circle; and when in the future there shall exist a system more extensive than that of the present standard and exceptional gauges combined, wonder will begin to arise as to the history of the great change, and to whom the reform was due.

We propose in this article to place on record the history of the narrow gauge movement, both for the information of the public at the present time, as well, and more particularly for future reference. And we consider this to be a special duty, not only because we have ourselves been almost uninterruptedly advocates of reduced gauge, but also because we consider that the real authors of the reform should receive their due acknowledgment, while we are convinced that unless such a record be made, it would not be long before a multiplicity of claimants would dispute for that which was not, and never had been, their own.

It is just 8 years since the Festiniog Railway, with a 2 ft. gauge, constructed in 1833 as a horse tramroad, was converted into a steam-worked railway for the conveyance of passengers, and of the slate quarried from the Festiniog hills, to be shipped at the quay of Portmadoc. This change of the horse-worked tram into a locomotive-worked railroad may be considered as one of the first steps towards the advancement at which we have arrived to-day. The Festiniog railway was not, it is true, the first steam-worked line of an exceptionally narrow gauge. Not to revert to the early days of tramways, there was the Broelthal Valley Railway, near Cologne, with its 2 ft. 7 in. gauge, already in operation. The Queensland line, 3 ft. 6 in. in breadth, had been surveyed, and practically adopted, based upon the experience obtained from a small railway of the same width in New Zealand. In Norway Mr. Carl Pihl was working out the problem that should give railways to an essentially poor country, in which English engineers had already proved the ordinary gauge to be commercially impossible by costly, even ruinous experiments.

But from English experience are obtained the data which govern colonial practice, and which guide Continental, and, especially American engineers ; and, upon the Festiniog Railway the only available experience as to efficient working of narrow gauge railways was to be obtained in this country. But although it is 8 years since the change was first made upon that line, and although independent engineers have been independently working out the question of cheap railways, based on a reduction of gauge, ever since that time, it is only some 2 or 3 years since the great reform began to be seriously and systematically agitated.

It is worth while reviewing briefly the part that the Festiniog Railway has really played in the matter of this railway reform we are considering. But for the energy displayed in bringing the capabilities of that line prominently forward, and showing all that it could do with efficient mechanical appliances, there would have been no experience, only theory to guide, and the question of reduction of gauge in its general application would probably have been thrown back for another 10 years. So much has been talked and written about the Festiniog line, so much is it quoted everywhere, that the whilom slate tramway has been brought into a celebrity unsurpassed even by the Great Pacific Railroad ; and it is this notoriety that leads many to unfavorable criticism, and to the publication of their opinions, that the railway has been simply used as an advertisement to further personal interests. It is urged among such that the traffic upon the line is small, that the freight is of the heaviest, most close-lying description, that all the gradients are in favor of the load, and that, under these circumstances, the duty it performs is simply proportioned to its size, whilst the

special class of engines running upon it have everything notoriously in their favor for the production of good results. By this, and similar specious arguments, a certain number of conservatives, or those impelled by actual personal motives, misrepresent the *rôle* of the Festiniog Railway, just as much as do some of those holding other views, who, led by their exuberance of feeling on seeing what can be effected on a gauge less than 2 ft. wide, run off straightway, and cry out for 2 ft. everywhere.

For its special duties the Festiniog Railway has an ample width; it has to convey but comparatively few passengers, and a considerable freight, measuring only some 15 ft. to the ton, which permits the rolling stock to be of the most simple description, so that the trucks upon which the slates are conveyed are small and low, while the passenger carriages are suited to the requirements of a somewhat primitive people. But for ordinary traffic, such a gauge would be utterly unfitted; the maximum width of vehicles that could be placed upon it would be insufficient for the purpose of general goods or passenger traffic, although ample engine power could be placed upon it to meet its utmost requirements. Thus both unreasoning and unreasonable advocates and opponents of narrow gauge, judge the Festiniog Railway in a false light, and fail to see that it was the only line in England upon which the problem could be worked out with anything like completeness, just as they fail to appreciate fully the importance of the results that have been obtained. It is true that all this time there existed a system of railways in Norway whose width had been carefully and judiciously selected with regard to the requirements of a general traffic, that there the question had been worked out thoroughly upon the most economical model. But except from the written and published data as to the performances and capacity of these lines written by their able engineer Mr. Pihl, those railways were unavailable for the advantages of experience. Add to this that the traffic returns in that country are too slight to afford any idea of the ultimate capacity of a narrow gauge railway, and that the engine power employed was proportioned to the traffic necessities, and it will be readily understood why it was impossible to obtain ultimate data. On the other hand, the Festiniog Railway lay close at hand, with its steep gradients running down towards its Portmadoc terminus, and its sharp curves, giving ample opportunity for conducting experiments inseparably connected with the subject. Moreover, the single element wanting had been supplied, thanks to the energy of Mr. Spooner, the superintendent of the line, and Fairlie engines were running on the road, and proving by their daily practice how large an amount of work could be done upon the tiny pair of rails with its heavy inclines and its narrow sweeps. Had the railway been 3 ft. 6 in. wide instead of a trifle less than 2 ft., half the ridiculous statements and assertions that have been made concerning it, and those connected with it, would probably have been spared.

Developed, then, as it had been by Mr. Spooner and Mr. Fairlie, the Festiniog Railway became a perfect experimental line, but nothing more. None of those connected with it have claimed more than this; it is only opposing argument and foolish advocacy that have endowed it with an undue importance. Nevertheless this little line was the cradle of the great enterprises now springing up on all sides. In 1869 the Russian Government, which had in some degree made itself acquainted with what had been done upon the railway, instructed the Minister of Public Works to invite Mr. Fairlie to visit St. Petersburg, to obtain information from him as to the capacity of his engines, and the experience which he had derived from the working of the Festiniog line. The result of this interview was the appointment by the Emperor of Russia of a Commission instructed to proceed to England, and investigate the truth of the favorable statements made in Mr. Fairlie's report. The Commission arrived here, as will be remembered, the president being the Count Alexis Bobrinsky, and the members various eminent Russian engineers, who, together with General Sir W. Baker, Captain Tyler, and others, visited the Festiniog Railway, and took much trouble to satisfy themselves, not only as to the truth of the statements which had been made to them, but also with regard to the relative efficiency for general traffic of cheap lines based upon the experience given by the Festiniog

Railway with its special duties. We need not refer now at any greater length to these proceedings; it is sufficient to remind our readers that, guided by what they had seen, fortified also with the experience of the 3 ft. 6 in. Norwegian system, the Russian Commission returned to St. Petersburg, and submitted such a report, that during the following May, after the matter had been discussed at a convocation of all the leading scientific men in Russia, the Emperor decreed the immediate construction of the Imperial Livny Railway with a 3 ft. 6 in. gauge, commencing at or near the Vierhovia station on the Orel and Eletz Railway, and terminating at Livny, a distance of 39 miles. The works were set in hand last summer, and completed the November following, despite the unusually inclement season of last winter. This railway was not, however, opened to the public till last March, owing to a delay in the delivery of the rolling stock and engines.

The energetic action taken by Russia in this question was due entirely to the experience obtained in Wales, and the same may be said with regard to the decision more recently made upon the future gauge for India ; in consequence of the reports of Captain Tyler and those members of the Indian Council who accompanied the Russian Commission, the Secretary of State for India forwarded to that country the responsible statements which had been brought under his notice. The result of this action was, that another Commission was sent to Wales, consisting chiefly of the leading engineers and others connected with the Public Works Department in India—of the number we may mention Colonel Strachey, Colonel Dickens, Mr. Stanton, Mr. Luard, etc., besides Mr. Rendel and others. Here experiments similar to those which had convinced the Russian Commission were repeated, and the results with reference to the Indian engineers were much the same. Colonel Strachey, Colonel Dickens, and Mr. Rendel reported, as may be remembered, in favor of a gauge 2 ft. 9 in. wide, whilst Mr. John Fowler, taking up the question on a broader basis, in fact, the basis upon which we have always argued this question, came to the conclusion that the balance of advantages rested with a gauge 3 ft. 6 in. wide. The 3 first named gentlemen, however, who had been instructed to report, struck with the capability of the Festiniog Railway, expressed their conviction that a gauge but little exceeding 2 ft. would be sufficient for Indian requirements. But guided by mature consideration, they advised the adoption of 2 ft. 9 in. as the new Indian standard. Supreme decision alighted between these two recommendations, and established 3ft. 3 in. as the future Indian gauge. Indisputably this result was brought about by the previous action of the Russian Commission, and the facilities afforded by the Welsh line.

So far we have shown that in two vast countries where established gauges previously existed, and in one of which, at least, there flourished, directly and indirectly, in the shape of opposing acting resident engineers, and opposing consulting engineers at home, the most violent antagonism, the new system has taken a firm footing, and must without doubt be extended rapidly during the next few years.

We next pass to our remote colonies of Australia and New Zealand and to the United States. In the former, as we stated last week, the keenest agitation exists on the subject of narrow gauge railways, combined with the most earnest determination of overthrowing the existing practice, which has proved absolutely ruinous to the interest of the colonies. In a country of such vast distances as Australia, a country thinly settled, for the most part agricultural, where favorable localities are either widely separated from each other or from commercial centres, railway communication means life, the absence of it stagnation and paralysis. Yet it is as impossible in Australia, as it was proved to be in Norway, to construct the old types of railways. The English experience of to-day gives to the colonists that which they require, in exchange for the stereotyped practice of an antiquated professional generation. Here, again, Festiniog Railway experience has done its work so completely and satisfactorily that already the broad gauge engineers engaged in Australia must resign their posts, or fall in with the inevitable changes.

And if this determination be so conspicuous at the Antipodes, it is no less strongly marked in the United States. Already there exists there a railway system, for the most part of the ordinary

gauge, of many thousand miles ; but this extent, vast as it is, covers but a small portion of the country with an effective network. In the Eastern and Central States, where great highroads of travel have been built—main lines and branch lines—the necessity of a sub-system is urgent. The State of Massachusetts is seeking to obtain a Bill authorizing the construction of narrow gauge roads, and its example will be followed by many other States. But in the western parts of the Union, not to speak of California, where the system is so thoroughly established that the present standard will soon become the exceptional gauge, the necessity for such roads is most keenly felt and most earnestly advocated. Vast tracts of land now lie idle, they require only occupiers to swell the revenue of the country. Such lands may be rich in timber, in soil, in pastures, in minerals, but, lying far removed from railway communication, they now form but so much fallow wealth. To unite such districts with the town centres, and the seaboard, to place them within the reach of colonization, and to enable them to obtain supplies, and to export their produce, in such a manner as would encourage emigration, can only be effected by the cheapest of cheap railways. It is no wonder, then, that the American engineer, seeing the practicability of such lines, hesitates but little in embarking wholesale into ventures that are sure of success. That they have not at an earlier date adopted narrow gauge railways to a large extent, may be explained by the fact, that in any radical change the American engineer looks to England for guidance, but having once seen a problem, whatever it may be, worked out, he puts it into rapid and extensive execution, whilst we, more soberly, are thinking of it.

We have thus sketched the history of narrow-gauge railway reform, a reform which, as it involves that evil so terrible to old-fashioned engineers—a break of gauge—has been, according to Mr. Bidder, "conceived in ignorance and maintained in folly," and we have seen how this same ignorance and folly, having infected the best engineers' brains in Russia, has spread to India, has become malignant in Australia, now rages in America, and that this radical epidemic has spread from the little spot in the Welsh hills. It remains to be seen who are the real agents in bringing about the change which is so largely superseding the empirical 4 ft. $8\frac{1}{2}$ in. gauge, and has, to all intents and purposes, taken the place for future works of the uselessly extravagant 5 ft. 6 in. Indian gauge.

So quietly has Mr. Carl Pihl proceeded with his work of providing Norway with railways suitable to her means, that little or nothing would have become known to the public as to the doings of that able engineer but through the influence of this journal, and even after we had made known to every one that his system of narrow-gauge lines was perfectly successful, but few English engineers, and fewer continental ones, have had the opportunity, or taken the trouble, to avail themselves by personal observation of the experience there to be obtained.

On the other hand, the chiefs of the whole railway world are individually acquainted with Festiniog, and on that imperfect, because entirely special line, they have seen and been able to judge for themselves. But this new railway, for the purposes of estimation and comparison, would have been as useless in its early steam days as it was when horses toiled up and down its gradients with the slate trolleys, had not the special locomotive appliances, which have helped to make it celebrated, been added to it. It was the addition of those engines a few years ago that first brought Mr. Fairlie into connection with the railway, and gave him the occasion for learning the real capacity of a small line, as well as the full advantages of his system of engines. What the general advantages of these latter are we have too often and too fully considered, to repeat here; all that is necessary to say now is, that without them extremely narrow gauge railways cannot be efficiently worked, and no line can be worked up to its full capacity. Having by years of labor established the fundamental principles of his system, Mr. Fairlie commenced the work which is now so fully crowned with success. At public meetings, in private gatherings, before scientific societies, in the press at home and abroad, he labored to show the evils of the existing system, the possibility of an improved one. In one form or other he has continued this work for nearly 8 years, and his contributions to railway literature on this subject are now more

read, more considered, and more quoted than that of any other author or authors. By unceasing work against unceasing opposition he has fought almost unaided in the cause, and though he commanded a limited audience, and had brought over a few earnest thinkers, it was only after the visit of the Russian Commission that his success began. In that act he had done more unhelped than any combination could have hoped to do. A prophet is without honor in his own country, and in St. Petersburg he received the consideration and attention denied him here. The conclusions of so important a Commission stirred the Indian Government, and this time Mr. Fairlie, who had made the Festiniog line that which it is, obtained a partial hearing, his presence being necessary on the occasion of the inspection. That he was not consulted, after having been made use of, was unfortunate, but perhaps natural; but by this time the almost incredible quantity of essays, lectures, and information he had circulated abroad, began to take effect, and at the present time it is scarcely possible to read any newspaper published in Australia or the United States without a reference to himself or his work. In the latter country especially, beyond the information obtained from our columns relative to the Norwegian lines, his writings on the subject are quoted, to the exclusion of anything else. His advice is sought from almost every State in the Union, and today he is the one great English railway authority in America. The acknowledgment still withheld here is freely accorded to him on the other side of the Atlantic; it may be because American engineers hail with alacrity any one who points out new truth, and shows the way to progress; it may be because, in the United States, there exists none of that jealousy and mistrust towards a foreign engineer which, with some few exceptions, have been the sole recognitions accorded by English engineers to Mr. Fairlie in this country. In fact, it is scarcely too much to say that there are no narrow gauge undertakings incorporated in the States without his direct advice and assistance, whilst his views are accepted both in relation to his engines, and also to the special gauge of 3 ft., which he has made his own, and which is now well known as the "Fairlie gauge."

In Russia, the principles he has advocated have been entirely followed, with the exception that the width adopted is that of the Norwegian standard. In all other respects the Livny Railway is essentially a cheap line, with steep gradients and sharp curves. Upon it the Fairlie engines are at work, developing results which surpass the greatest expectations of the Russian engineers who recommended them, and who are unanimous in their opinion that to insure a complete railway success in this country the whole of the new network of lines must be worked by them. The soundness of the policy advocated by Mr. Fairlie will be further tested by a series of trials, made by an Imperial Commission, upon the result of which the full adoption of his engines for Russia will depend. These trials we shall shortly publish; meanwhile we may say that the experience already obtained has brought the matter to a foregone conclusion.

Thus in America, Russia, and Australia, we find that at present Mr. Fairlie meets with just appreciation, always excepting the babbling jealousy of a few engineers in the latter colony who are fighting a bad cause to the last. And the time cannot be long distant before in this country, also, he must receive a fair acknowledgment of his labor. To depreciate at first, and afterwards to attempt to appropriate, is a human failing, and in the full consciousness of this we have, as we stated at the commencement, written this article. We have not written to aid Mr. Fairlie; there was a time when he needed help, and it was freely rendered by ourselves and by our contemporary, "The Engineer," but that time has passed now; the principles of opposition against him, "conceived in ignorance, maintained in obstinacy," as Mr. Bidder would say, are passing away; and to-day Mr. Fairlie has attained more than a realization of his expectations and his hopes. He has achieved popularity and success to an exceptional degree, and can well afford now to wait till opposition shall be converted into applause and—imitation.

But despite the clearest and most incontrovertible facts, there will not be wanting those who, in the course of a short time, will urge their right to be considered as the authors of the railway reform we have been considering. But

these will walk in a false light, and talk under false pretences; and it is certain that so long as this article shall be read, so long as it shall continue in existence, it will remain an unimpeachable testimony in favor of the man who has devoted the best years of his life to the establishment of narrow-gauge railways, and has won success.

SUBMARINE ROCK SURVEYING.

By G. H. MANN, C. E.

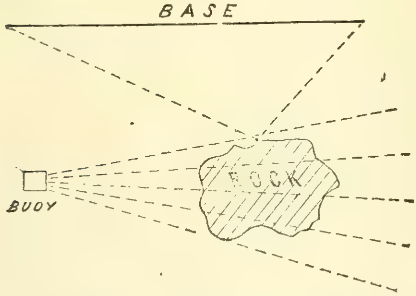
Submarine rocks may be of either of two general classes:—

1*st. Inshore Rocks.*

2*d. Isolated Rocks.*

Points on the first class can be accurately determined by instrument intersections, but on the second can not, on account of the distance from the shore. It is an important condition in rock surveying that the method employed should not only give the soundings in their proper relation to each other, but also so arranged as to render easy the passing of contour lines upon the map. In waters without currents, straight lines of soundings can be readily run, without anything besides the oars to hold the boat in position. For inshore rocks, lines of soundings can be run from ranges, and the soundings located by 2 instruments on shore. For isolated rocks, 2 boats may be moored, so as to allow but little motion, and used for the extremities of a base, whose length and bearing may be determined. The lines of soundings being run from a barrel buoy, or 2 of them, anchored outside of the rock, the system of lines in the two cases being shown in the figures.

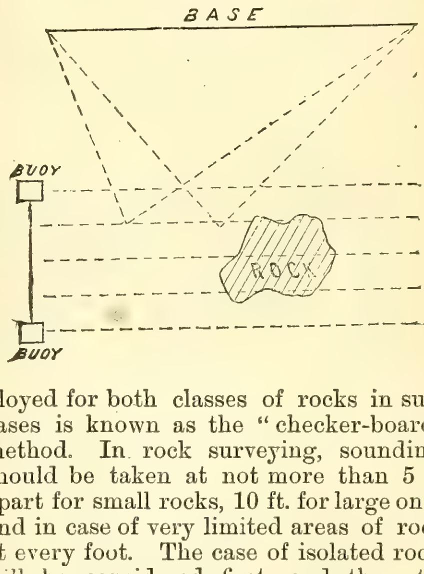
Fig. 1.



If the ends of the base are visible from the shore, they may be located, and the position of the rock thus determined.

In currents, some other means of surveying must be employed, as it is impossible to hold a boat in position by oars alone under such circumstances. As an initial condition, it should be stated that the lines of soundings should always run with the current. The system to be em-

Fig. 2.

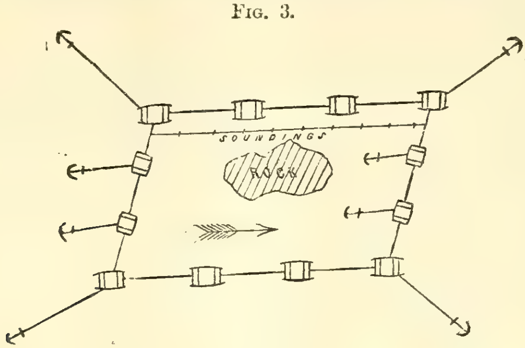


ployed for both classes of rocks in such cases is known as the "checker-board" method. In rock surveying, soundings should be taken at not more than 5 ft. apart for small rocks, 10 ft. for large ones, and in case of very limited areas of rock, at every foot. The case of isolated rocks will be considered first, and then the modifications desirable for inshore rocks. Having first made careful soundings around the rock, set small barrel buoys so as to show the extent of the rock. Kerosene oil barrels are then strapped, with eyes opposite each other, on the upper and lower side; 4 of them are then anchored so as to include the whole of the rock, the warps being long enough to prevent dragging the anchors. (See Fig. 3.)

These rocks are then strung up in the form of a parallelogram by ropes passing through the upper eyes, and having pieces of red bunting inserted into them at the intervals at which soundings are to be made. For long lines, other barrels must be anchored, as shown, to prevent sagging. A line (l), marked as above, is

then stretched from one parallel side to another, and fastened, the soundings being taken by moving the boat along it, and sounding at every tag. It is then moved along the parallel lines to the next tag, and soundings are thus taken until the whole rock is included. The angle between the base and the sounding line is then taken with a sextant, and the bearing of the base determined. The line of soundings should always start from the side *from* which the current runs. If the current (as in some harbors) changes its direction so as to run across the line of soundings, it is then best to locate them by taking the angle between the line and

FIG. 3.



the base at every sounding. In case of long reefs this should be done, as in such places it will not always be possible to have the lines run in the direction of the current. For very large rocks, the method of a base and two sextants may be advantageously employed in connection with the "checker-board" method. For inshore rocks, the lines need not be marked, but are used simply for the purpose of holding the boat while angles are being taken with the instruments on shore. If thought desirable, the "checker-board" method may be employed, and the buoys located from on shore; for one instrument this is very convenient.

PUBLIC MONUMENTS.

From "The Building News."

The subject of public monuments, and especially effigies of great men, is now under constant discussion, owing to the proposals to adorn the ornamental spaces contiguous to the Houses of Parliament with statues of British statesmen. Few questions of the kind are more difficult, and few are more interesting. We have never in these matters been celebrated. The interiors of St. Paul's and Westminster exhibit a lamentable confusion of mortuary trophies, with which art has had nothing whatever to do—masses of marble, carved enormities and unnatural symbolic groups, in nearly every instance Pagan in design. But, at present, we refer more particularly to open-air statues, though, in passing, it may be noticed that our triumphal columns are generally better placed. That the Doric pillar on Fish-street-hill appears to little advantage is due less to any fault of the architect than to the gradual rising of the earth around its base, and the crowding of the locality with buildings. The Duke of York's Column is nobly pitched, and would be a magnificent ornament to London, were it not for the hideous cage near the top, which suggests once for all that a commemorative pillar should be a monument, and not an observatory, and that the necessity for these disfigurements is utterly artificial. Much criticism has befallen the Nelson Monument in Trafalgar square; but it is of imposing aspect, nevertheless. It is when we come to the *al fresco* effigies of our historical characters that London chiefly fails—not merely in their forms as works of art, but in the situations in which they are erected. Trafalgar square, not long ago, suggested the idea of a lately opened cemetery, with Nelson on a

towering column, Havelock on a pedestal, Jenner in a chair, and the other heroes on horseback. The equestrian effigy of Charles I. is exactly where a statue should be, at a confluence of great thoroughfares and looking down a splendid perspective. Contrast it with the image of Mr. Peabody, disgracefully thrust into a corner at the back of the Royal Exchange. That of James II. at Whitehall is out of sight. As for the others, in the squares they would be decorative if Englishmen understood what a square should be; but they do not. That of Trafalgar is the only one, in the true sense of the term, which our metropolis possesses. The others are mere gardens, railed in and planted. Soho, St. James's, Cavendish—where stands a monument of English shame rather than one of any great man's greatness—Hanover—where a really good figure of Pitt, Chantrey's work, stands in not the worst of positions—Bedford and Russell squares, are all miniature and exclusive parks, each adorned with a statue; but these memorials are not, within the strict meaning of the word, public. Well, to sum up, we have in London 13 images of kings and queens, if it be possible to include the ghastly skeleton in Leicester-square, 3 Wellingtons and 1 Nelson, 3 statesmen, 1 Radical Reformer of the olden type, and 1 popular benefactor of the same class. These are of a far higher order than the absolutely modern works, and not one of them, however secluded, but puts to shame the gross caricature of Richard Cobden's noble figure and features which disfigures the chief thoroughfare of Camden Town. We say nothing of the images erected on the Holborn Viaduct, because they are merely typical, and really adorn the structure, or of the effigies proposed to be niched in Westminster Hall, since that it is not "open-air;" but we would refer to the preposterous Guards' Memorial in Waterloo Place as an example of vulgar clumsiness. Who that has seen the monuments of Goethe and the Three Printers at Frankfort, and that of Rembrandt, at Amsterdam, can fail to take in our meaning? Nor have the French less capacity for erecting stately memorials (albeit for pulling them down also) and fixing upon appropriate sites for their disposition. Never in Paris would have been seen such a grotesque as the Trojan Horse on the top of the arch at Hyde Park Corner, or the Achilles in the corner of Hyde Park. This question is becoming all the more important, not merely on account of the sculpture about to be distributed in the neighborhood of the new Palace of Westminster, but also in anticipation of the statuary which it is proposed to range along the line of the Thames Embankment. The public must be anxious to save this noble thoroughfare from disfigurement and disgrace. But the curious point is, what is the public sense, what is the general expectation upon this subject? Both, undoubtedly, have made great advances. We cannot conceive, in our days, a naked General Wolfe, crowned by a glory, and upheld by a Grenadier; Admiral Holmes as a Roman; Captain Blair riding a sea-horse; Pitt sitting to History, which paints his portrait; Percival lying on a mattress; Sir John Moore receiving a laurel wreath from the Spaniards—of all nations!—or those other allegorical absurdities which were the delight of two or three generations ago, and, indeed, until a later time. Meanwhile, a proposal has been made to classify our public memorials, to reserve cathedrals and abbeys for divines, with, it is presumed, poets, writers, and statesmen, though the rule, strictly applied, would relegate these last to the Houses of Parliament; the inns of court and the courts of justice for jurists; the Halls of medical colleges or of hospitals for eminent medical men; the university halls for men of learning; and the halls of our scientific institutions for men of science. We very much doubt whether any such arrangement would ever satisfy the sentiment which proposes to erect the memorial of a great man. Not that sculpture creates fame, except for the sculptor; but that it is an outward and visible manifestation and proof of it in the eyes of posterity. It would be a mistake to shut up the image of an antiquary among antiquities, or that of a great anatomist among the specimens in the Royal College of Surgeons. But, we repeat, the grand essential is to study what we have, and the possibility of rising to a higher style as to the conception, execution, and settlement in permanent places of our public materials. There does not exist in London a solitary example worthy of being taken as a model; not even "the masterpiece of Grinling Gibbons," as guide-book makers, following one another

with slavish monotony, pronounce it, which we heartily wish had been melted down long ago into knife and fork handles ; or that respectable imitation of a Corinthian column, the Nelson Monument, crowned by the somewhat anomalous cocked hat of our naval hero; or Chantrey's George IV. in the attitude of a Brighton riding-master ; or the idiotic majesty, though well pitched, of George III., in Cockspur street ; or Sir Henry Havelock, in the attitude of a soldier at ease, but with the expression of a Methodist preacher; his companion, Sir Charles Napier, looks like a conceited corporal who has just been complimented by his adjutant. We have noticed the Guards' Memorial, which resembles nothing more than a pastry-cook's trophy ; but not the Westminster Boy Memorial, which hath the likeness of a dry drinking-fountain. Oddly enough, one of our best specimens —that of James II.—stands purgatorily in a dirty yard off Whitehall, instead of being placed, for instance, at the intersection of two such streets as Oxford street and Regent street—spots which would not be required exclusively for lamps if our thoroughfare lighting were at all decent. There is Lord George Bentinck, shrouded in the obscurity of Cavendish square ; Queen Elizabeth outside, in a disused church-yard; and Queen Victoria inside the Royal Exchange ; and George Stephenson consigned to a railway station. Not any of these can very rapturously be recommended. Sir Robert Peel, at the top of Cheapside, occupies an excellent position, as does William IV. in view of London Bridge ; but where is Cœur de Lion, after his many mutations? —this statue has always been a sort of nightmare in the sculpture world of England—and where is George Canning, who was so long his maltreated colleague? Let us note a few incidents connected with some of these. That of Pitt, in Hanover square, is without outline—the great fault of our public statues—being muffled up, obediently to a ridiculous tradition, in a semi-Classic, semi-Red Indian, or blanket, toga ; that of the Duke of Kent, at the upper end of Portland Place, is nearly smothered among architectural accessories ; Chantrey's George IV., in Trafalgar square, though equestrian, is also togaed; that of Jenner, though Trafalgar square has been relieved of it, has been doomed to sit among the verdure and water of the Old Court suburb, where it some day may be mistaken for a river god ; indeed, the catalogue, and the criticisms upon it, might be almost indefinitely extended. But a final word of advice to young sculptors who have opportunities of travel. If their school be heroic, let them mark the genius which created Peter the Great at Moscow, and Frederick the Great at Berlin ; or, if otherwise, a single monument in Paris may change many of their preconceived ideas—the statue of Moliere, in the Rue de Richelieu, which is perfect. It will be perceived that we have omitted all mention of the Albert Memorial ; but this has been purposely.

A strange phenomenon was observed at Delft last year during the operation of boring for water. H. Vogelsang has described that on Aug. 3d, the iron tube had been driven to a depth of 17.5 metres through a bed of alluvium, when gas began to rush up the tube with great violence, followed by a stream of water. The foaming column rose 14 metres into the air, and played for 14 hours without intermission; it then appeared after intervals of 9 min. The intermittent activity lasted till the 21st, and terminated with an evolution of gas alone. The water, when the irruption commenced, contained much iron in the form of carbonate, and had a temperature of 13 deg. Cent. The gas burnt with a large but feebly luminous flame, and was composed, on the 6th of August, of 16.4 volumes of carbonic acid to 83.6 volumes of marsh gas; and on the 16th of the same month, of 11.6 volumes of carbonic to 88.4 volumes of marsh gas. On the 21st the tube was driven further, and at a depth of 30 metres, a supply of water reached.

The Joint Committee of the Great Western and Midland Railway Companies' Clifton Extension have resolved to proceed without further delay with the construction of this branch railway. The line is about $3\frac{1}{4}$ miles in length, and will bring this fashionable suburb of Bristol into direct communication with those railways, and with the Channel docks now in course of construction at Avonmouth.

THROUGH THE EUPHRATES VALLEY.

From "Engineering."

The question of the construction of a line of railway connecting the Mediterranean Sea with the Persian Gulf, as an improved means of communication with India, is one that has practically been before the country for upwards of 40 years; it has already on a former occasion received encouragement from the English Government, and it is with no small degree of satisfaction that we find that it is again to be considered in Parliament, in all its details, by a Select Committee. The early history of this route as a passage between Europe and India has so recently been reviewed in these pages that it is not necessary to go over that ground again. In the discussion on the subject which took place in the House of Commons, some of the leading characteristics of such an alternative route to India as the one proposed were dwelt upon, but owing to the readiness with which Government consented to the appointment of a Select Committee, doubtless many valuable opinions on the subject remain unrecorded which would otherwise have been then advanced in favor of Sir J. Jenkinson's proposition. Whether that motion had its origin in a desire to support any particular project, we are unable to say. In our minds the subject is one of imperial importance to this country both in a political and military sense ; it was also shown in the discussion that England had a large interest commercially, first, in its construction, and subsequently in its use, and that to such an extent that some pecuniary assistance towards its establishment seemed to be justifiable, although most of the speakers on the subject appear to have been adverse to the giving of a guarantee for the cost of its construction.

Although certain Members of Parliament appear to have been in favor of limiting the scope of the investigations to be entered into by the Select Committee, it is to be hoped that no such restriction will be placed upon them, for the necessity or advisability of constructing a new highway to India depends, not upon one or two considerations, but upon all the points that may be advanced for or against it. India is now, perhaps, of as much importance to England as England is to India, and any means that can be devised for bringing these two mutual dependencies nearer together, must be of considerable advantage to both of them. Now it has been shown that a railway connecting the Mediterranean Sea with the Persian Gulf, would shorten the actual travelling distance by 1,000 miles, and the time of transit by one week. So direct, too, is the route, that a straight line drawn from London to Bussorah, passes through the very country that would be traversed by the proposed railway. As regards the actual route to be taken, much must, of course, depend upon the results of the actual surveys of the alternative lines that have been proposed. Mr. W. P. Andrew has long been a strong and consistent advocate for the Euphrates Valley line, and, it must be admitted, that it is in a great measure due to his energetic perseverance in advocating his pet scheme that the subject is now likely to enter upon another phase. Amongst the many disadvantages of the Euphrates Valley route, it possesses this one special advantage, namely, that it has been surveyed throughout its entire length, which is more than can be said of any other line. As a through route only, it might perhaps be as good as any other, but through traffic alone is not likely to prove remunerative for a line of railway 850 miles in length, which should, therefore, be carried as much as possible along, or near to, the natural course of the traffic of the country through which it is to pass. Taking for granted that it will be considered preferable to have the western terminus of the railway on the Mediterranean rather than on the Black Sea, the valley of the Tigris presents many advantages over its sister valley for a railway route, possessing, as it does, many important towns between which there exists a considerable amount of traffic already in existence, and it now forms the commercial highway across that part of the country. That the Tigris route is of more importance commercially than the line of the Euphrates has already been sufficiently acknowledged by the construction of the telegraph line in that direction, and

it would be but a rational conclusion that, from a commercial point of view, the telegraph and railway should follow the same route. From political or military considerations it would also probably be found desirable to follow the most populous and frequented route; but the questions as to practicability and cost can be substantially determined only upon actual surveys, although the probability is that the existing trade route has been formed, to some degree, from the natural advantages for traffic presented by the line of country which has now for many centuries maintained its existence. The physical difficulties of the proposed railway must form a not unimportant point for consideration, as upon it so many other questions depend, and no investigation can be complete that is not based upon this as one of primary importance.

It would hardly be wise to leave out of consideration the question of cost, and probable remuneration of any proposed line that may commend itself to the Select Committee upon other grounds. Whatever be the character of the railway to be constructed—whether of broad or narrow gauge, of single or double line of way—these questions will be unaffected in principle, for the line that is best for one class of railway will most likely be found—with very trifling variations—to be best for the other. Advocates for both broad and narrow gauges will doubtless put in an appearance before the Select Committee ; their differences of opinion will, however, only have a relative effect as regards the relation of probable returns to capital outlay, which must, under any circumstances, be more favorable to the narrow-gauge advocates. This, however, is a detail, which, though it cannot be entirely overlooked by the Committee as affecting the probability of the line being taken up by capitalists, may in a great measure be left for ultimate determination. With regard to cost, and the means of constructing any line that may be recommended for adoption, it was originally estimated that the Euphrates Valley line would cost about £8,000,000. That was before the days of narrow-gauge lines. Mr. Fairlie has, in a recent letter to the "Times," set down the probable cost of a 3 ft. line at £4,000,000, or an average of about £4,500 a mile. On the 27th of September, 1856, the Earl of Clarendon forwarded a telegram to the Chairman of the Euphrates Valley Railway to the effect that it was expected that the Sublime Porte would guarantee 6 per cent. on a capital of £8,000,000 for a railway from the Mediterranean Sea to the Persian Gulf (see the "Times" newspaper for the 21st of November, 1856), and the Turkish Government appears to be still favorable to such a project, which could not but greatly affect the prosperity of the country. Without the aid of some Government assistance—whether in the shape of a subsidy, or guarantee either of cash, or, what would be an equal equivalent, of a certain amount of traffic—it is not likely that funds will be easily obtained for such a large undertaking. If, however, the Sublime Porte could be induced to offer a small guarantee, and our Government to promise the Indian mails and a certain amount of traffic annually, there ought to be no difficulty in carrying out any project that the Select Committee may ultimately recommend. If any railway to connect the Mediterranean with the Persian Gulf can be constructed for, say, £5,000,000, and be maintained only by its own traffic, without giving any return for capital, it would surely prove a more remunerative scheme for this country than doing away with purchase in the army, and as such we recommend it to Mr. Lowe as an item for his next budget.

The whole question of course turns upon the importance of improving our means of communication with India. It has been shown that a railway connecting the Mediterranean with the Persian Gulf would lie in the most direct line between this country and India. Having its termini on two seas, it could easily be held and defended by our navy, which would be very important in the event of any disturbance on the part of Russia on our Eastern frontier, or in the event of our being suddenly and unexpectedly called upon to carry out our treaty obligations with respect to Turkey.

Road Steamers in Brazil.—Privileges have been granted in the Brazilian province of Rio Grande do Sul for two roads intended for Thomson's road steamers.

THE MANUFACTURE OF RUSSIAN SHEET-IRON.*

From "The Builder."

A particular kind of sheet-iron is manufactured in Russia, which seeems not to have been produced elsewhere. It is remarkable for its smooth, glossy surface, which is dark metallic gray, and not bluish gray, like that of common sheet-iron. On bending it backwards and forwards with the fingers, no scale is separated, as is the case with sheet-iron manufactured in the ordinary way by rolling ; but on folding it closely, as though it were paper, and unfolding it, small scales are detached along the line of the fold.

This sheet-iron is in considerable demand in Russia for roofing, and in the United States, where it is largely used in the construction of stoves and for incasing locomotive engines. It is there named stove-pipe iron.

Russian sheet-iron has been recently subjected to chemical examination in the Metallurgical Laboratory of the Royal School of Mines, and the analytical work has been executed by Dr. Percy's assistant, Mr. W. J. Ward.

The occurrence of a peculiar carbonaceous mass, left after the solvent action of dilute hydrochloric or sulphuric acid, may reasonably be accounted for, Dr. Percy says, by the method of manufacturing Russian sheet-iron, which he describes. The sheets are interstratified with charcoal-powder, and bound up in packets, each of which is subjected to repeated hammering. Hence, it is easy to conceive how fine particles of charcoal should be beaten in over both surfaces of each sheet ; and, if this be so, a relatively larger proportion of carbon should exist in the thin sheet, as is the case. Yet that some of the carbon is combined, may be inferred from the fact that distinct hardening occurs after heating the metal to redness, and immersing it while hot in water, and especially in mercury.

In the volume on iron and steel, which Dr. Percy published in 1864, he stated that the mode of manufacturing the Russian sheet-iron in question was kept rigidly secret ; that it was made from iron smelted and worked throughout with charcoal as the fuel ; that according to information which he had received from three independent sources, the sheets, after the completion of the rolling, were hammered in packets with charcoal-dust interposed between every sheet ; and that they were subsequently assorted, and the outer ones, being inferior in quality, were thrown aside as wasters.

Our author has since found that the secrecy was more dependent on ignorance of the Russian languange than on anything intentional ; and he now gives various particulars of the process.

The manufacture of sheet-iron in Russia, he says, is chiefly confined to the iron works on the eastern side of the Oural Mountains. The malleable iron, which is the subject of this manufacture, is derived from pig-iron, obtained by smelting the following ores with charcoal in cold-blast furnaces,—namely, magnetine, carbonate of iron (*sphœro siderite*),and red and brown hematite. The converson of the pig-iron into malleable iron is effected either in the charcoal-finery or in the puddling furnace.

The puddle-balls intended for the manufacture of sheet-iron, are rolled into bars 5 in. wide and $\frac{1}{4}$ in. thick. The iron should be more crystalline than fibrous, and should contain sufficient carbon to render it more like steel than iron. The machinery required consists of one or two pairs of rolls and two kinds of hammers. Reheating is conducted in furnaces of particular construction. The rolls are driven by water-wheels, and should make not fewer than 50 revolutions a minute. The hammers are also put in motion by cams on the axles of water-wheels. The hammer-heads are of wrought iron, with striking faces of steel. Each anvil consists of a solid block of white cast iron. It is necessary that the hammers and anvils should be so made, in order that they may have the requisite hardness, in default of which the surfaces of the sheets would not acquire sufficient brightness or polish.

The puddle-bars, 5 in. wide and $\frac{1}{4}$ in. thick, are cut into pieces 29 in. long, which weigh about 15.35 lbs. avoird. (10 lbs. ?—J. P.) These pieces are heated to redness, and cross-rolled into sheets about

* The Manufacture of Russian Sheet-Iron. By JOHN PERCY M. D., F. R. S., Lecturer on Metallurgy at the Royal School of Mines, etc. With illustrations. London : John Murray, Albemarle street. 1871.

29 in. square; and in order to become thus extended, they require to be passed through the rolls about 12 or 14 times. The sheets thus produced are arranged in packets of 3 in each, heated to redness, and rolled, each packet passing through the rolls about 10 times. But just before rolling, the surface of each packet is cleaned with a wet broom, usually made of the green leaves of the silver fir, and powdered charcoal is strewn between the sheets.

The sheets obtained from this rolling are sheared in the dimensions of 28 in. by 56 in. Each sheared sheet is brushed all over with a mixture of birch charcoal powder and water and then dried. The sheets, so coated with a thin layer of charcoal powder, are arranged in packets containing from 70 to 100 sheets each; and each packet is bound up in waste sheets, of which 2 are placed at the top and 2 at the bottom. A single packet at a time is reheated, with logs of wood about 7 ft. long placed round it, the object of which is to avoid, as far as possible, the presence of free oxygen in the reheating chamber. The gases and vapors evolved from heated wood contain combustible matter, which would tend to protect the sheets from oxidation in the event of free oxygen finding its way into the reheating chamber.

The packet is heated slowly during 5 or 6 hours, after which it is taken out by means of large tongs and hammered. The packet is moved so that the blows fall in an order indicated by diagram. After this treatment the surface of the packet presents a wavy appearance, as the striking-face of the hammer and the face of the anvil are both very narrow. When the packet has travelled about 6 times under the hammer, in the manner specified, it is removed; and immediately afterwards completely finished sheets are arranged alternately between those of the packet.

The actual cost of manufacturing these Russian sheets is about £12 15s. per ton, to which must be added general charges, which raise the amount to £16 or £17 per ton, exclusive of profit. The average price of sheet-iron at the fair of Nijni-Novgorod is about £22 or £25 per ton.

THE DISTRIBUTION OF TEMPERATURE IN THE NORTH ATLANTIC.*

By WYVILLE THOMSON.

From "Nature."

At the request of the Council of the Scottish Meteorological Society, I beg to bring before you a sketch of the more recent results of investigations into the causes of the abnormal climate of the surface of a great portion of the North Atlantic Ocean, and of the lands which form its north-eastern borders; and especially the results of the deep-sea exploring expeditions of the last 3 years, in which I have taken a part, so far as they bear upon this point.

In a recent valuable report on the Gulf Stream in the "Geographische Mittheilunger," of last year, Dr. Petermann severely, and, I think too, justly reflected upon us students of ocean temperatures for giving ourselves up to wild and gratuitous speculation. I wish, if possible, on the present occasion, to avoid all risk of such impeachment, by limiting our inquiry rigidly for the few minutes I have at my disposal, to the present condition of our knowledge of facts, and to such deductions from these as may be fairly considered proved.

Let us then first inquire for a moment what the phenomena are which we are called upon to correlate and to explain. There is no dispute about these facts, and a glance at the chart will at once recall them to your recollection. In the first place, the lines of equal mean annual temperature, instead of showing any tendency to coincide with the parallels of latitude, run up into the North Atlantic and into the North Sea, in the form of a series of long loops. This diversion of the isothermal lines from their normal direction is admittedly caused by surface ocean currents conveying the warm tropical water towards the polar regions, whence there is a constant counter-flow of cold water beneath to supply its place. This

* Address delivered to the Meteorological Society of Scotland at the General Meeting of the Society, July 5th.

phenomenon is not confined to the North Atlantic. A corresponding series of loops, though not so well defined, passes southwards, along the east coast of South America, and a very marked series occupies the north-eastern angle of the Pacific, off the Aleutian Islands and the coast of California. The temperature of the land is not affected directly by the temperature of the sea in its immediate neighborhood, but by the temperature of the prevailing wind, which is determined by that of the sea. Setting aside the still more important point of the equalization of summer and winter temperature, the mean annual temperature of Bergen, lat. 60 deg. 24 min. N., subject to the ameliorating influence of the south-west wind blowing over the temperate water of the North Atlantic, is 6.7 C., while that of Tobolsk, lat. 58 deg. 13 min., is 2.4 deg. C.

But the temperature of the North Atlantic is not only raised greatly above that of places on the same parallel of latitude having a continental climate, by this interchange of tropical and polar water, but it is greatly higher than that of places apparently similarly circumstanced as to a general interchange of water in the Southern Hemisphere. Thus, the mean annual temperature of the Faroe Islands, lat. 62 deg. 2 min. N., is 71 deg. C., nearly equal to that of the Falkland Islands, lat. 52 deg. S., which is 82 deg. C., and the temperature of Dublin, lat 53 deg. 21 min. N., is 9.6 deg. C., while that of Port Famine, lat. 53 deg. 8 min. S., is 5.3 deg. C. Again the high temperature of the North Atlantic is not equally distributed, but is very marked in its special determination to the north-east coasts. Thus, the mean annual temperature of Halifax, lat. 44 deg. 39 min., is 6.2 deg. C., while that of Dublin, lat. 53 deg. 21 min. is 9.6 C., and the temperature of Boston (Mass.), lat. 42 deg. 21 min., is exactly the same as that of Dublin.

We thus arrive at the well-known general result, that the temperature of the sea bathing the north-east shores of the North Atlantic is greatly raised above its normal point by currents involving an interchange of tropical and polar water; and that the lands bordering on the North Atlantic participate in this amelioration of climate by the heat imparted by the water to their prevailing winds.

We shall now examine this distribution of ocean temperature a little more minutely. During the last many years, a prodigious amount of data have been accumulating with reference to the detailed distribution of heat on the surface of the North Atlantic basin, and last year M. Petermann, of Gotha, published in his "Geographische Mittheilungen" a series of invaluable temperature charts embodying the results of the reduction of upwards of 100,000 observations derived mainly from the following sources :—

1*st.* From the wind and current charts of Lieut. Maury, embodying about 30,000 distinct temperature observations.

2*d.* From 50,000 observations made by Dutch sea-captains and published by the Government of the Netherlands.

3*d.* From the journal of the Cunard steamers between Liverpool and New York, and of the steamers of the Montreal Company between Glasgow and Belleisle.

4*th.* From the data collected by our excellent secretary, Mr. Buchan, with regard to the temperature of the coast of Scotland.

5*th.* From the publications of the Norwegian Institute on sea temperatures between Norway, Scotland, and Iceland.

6*th.* From the data furnished by the Danish Rear-admiral Irminger on sea temperatures between Denmark and the Danish settlements in Greenland.

7*th.* From the observations made by Lord Dufferin on board his yacht Foam between Scotland, Iceland, Spitzbergen, and Norway.

And finally from the recent observations collected by the English, German, Swedish, and Russian expeditions to the Arctic regions and towards the North Pole.

Dr. Petermann has devoted the special attention of a great part of his life to this question, and the accuracy of his results in every detail is beyond the shadow of a doubt. Every curve of equal temperature, whether for the summer, for the winter, or for the whole year, instantly declares itself as one of a system of curves which are referred to the Strait of Florida as the source of heat, and the warm water may be traced (and this is not begging the question, for the temperature is got by dipping the thermometer in the water), in a continuous stream, indicated where its movement can no longer be observed by its form, fanning out from the neighborhood of the Strait across the Atlantic,

skirting the coasts of France, Britain, and Scandinavia, rounding the North Cape, and passing the White sea and the Sea of Kari, bathing the western shores of Novaja Semla and Spitzbergen, and finally coursing round the coast of Siberia, a trace of it still remaining to try to find its way through the narrow and shallow Behring Strait into the North Pacific. Now it seems to me that if we had these observations alone, which are merely detailed and careful corroborations of many previous ones, and could depend upon them, without even having any clue to their *rationale*, we should be forced to admit that whatever might be the amount and distribution of heat derived from a general oceanic circulation, whether produced by the prevailing winds of the region, by convection, by unequal barometric pressure, by tropical heat, or by arctic cold, there is besides this some other source of heat at the point referred to by these curves sufficiently powerful to mask all the rest, and, broadly speaking, to produce of itself all the perceptible deviations of the isotherms from their normal course.

But we have no difficulty in accounting for this source of heat. As is well-known, about the equator, the north-east and south-east trade winds reduced to meridional directions by the eastward frictional impulse of the earth's rotation, drive before them a magnificent surface current of hot water, the equatorial current 4,000 miles long and 450 miles broad, at an average rate of 30 miles a day. This current splits upon Cape St. Roque, and one portion trends southwards to deflect the isotherms of 21 deg. 15.5 deg., 10 deg., and 4.5 deg. C. into loops, thus carrying a scrap of comfort towards the Falklands and Cape Horn. While the remainder, "having made the circuit of the Gulf of Mexico, issues through the Straits of Florida, clinging in shore round Cape Florida, whence it issues as the Gulf Stream, in a majestic current upwards of 30 miles broad, 2,200 ft. deep, with an average velocity of 4 miles an hour, and a temperature of 86 deg. Fahr." (Herschel.)

I need scarcely follow the course of the Gulf Stream in detail, it is generally so well known. After leaving the Strait of Florida, it strikes in a north-easterly direction, comformable generally to the easterly impulse given by its excess of diurnal rotation, towards the coast of Northern Europe. About 42 deg. N. a large portion of it, still maintaining the high surface temperature of 24 deg. C., turns eastward and southward, and, eddying round the Sargasso Sea, fuses with the northern edge of the equatorial current, and rejoins the main circulation. The main body, however, moves northwards. Mr. Croll, in a very suggestive paper in the "Philosophical Magazine" on Ocean Currents, estimates the Gulf Stream as equal to a stream of water 50 miles broad and 1,000 ft. deep, flowing at a rate of 4 miles an hour, with a mean temperature of 18 deg. C. I see no reason whatever to believe this calculation to be excessive, and it gives a graphic idea of the forces at work.

The North Atlantic and the Arctic seas form together a basin closed to the northward, for there is practically no passage for a body of water through Behring's Strait. Into the corner of this basin, as if it were a bath, with a north-easterly direction given to it, as if the supply pipe of the bath were turned so as to give the hot water a definite impulse, this enormous flood is poured day and night, winter and summer; almost appalling in its volume and the continuity of its warmth, and its blueness, and brilliant transparency, *in sæcula sæculorum!*

The hot water pours, not entirely from the Strait of Florida, but partly from the Strait and partly in a more diffused current outside the islands, with a decided, though slight north-easterly impulse on account of its great initial velocity. The North Atlantic is with the Arctic Sea a *cul-de-sac.* When this basin is full—and not till then—overcoming its northern impulse, the water tends southwards in the southern eddy, so that there is a certain tendency for the hot water to accumulate in the northern basin. It is to this tendency, produced by the absence of a free outlet to the Arctic Sea, that I would be inclined to attribute the special excess of the warmth of the north-eastern shores of the North Atlantic.

When ascertaining with the utmost care and with the most trustworthy instruments, by serial soundings, the temperature of the area surveyed by the Porcupine in 1869, we found at a depth of 2,435 fathoms in the Bay of Biscay, that down to 50 fathoms the temperature of the sea was greatly affected by direct solar radia-

tion ; from 100 to 900 fathoms the temperature gradually fell from 10 deg. C. to 4 deg. C., and from 900 fathoms to 2,435, the fall of temperature was almost imperceptibly gradual from 4 deg. to 2.5 deg. C.

The comparatively high temperature from 100 fathoms to 900 fathoms I am certainly inclined to attribute to the northern accumulation of the water of the Gulf Stream. The radiant heat derived directly from the sun must, of course, be regarded as a constant quantity superadded to the original temperature of the water derived from other sources. Taking this into account, the surface temperatures in what we were in the habit of calling the "warm area" coincided precisely with Petermann's curves indicating the northward path of the Gulf Stream.

It is scarcely necessary to say, that for every unit of water which enters the basin of the North Atlantic, an equivalent must return. From its low velocity, the Arctic return current or indraught will doubtless tend slightly to a westerly direction, and the higher specific gravity of the cold water may probably even more powerfully lead it into the deepest channels; or, possibly, the two causes may combine, and in the course of ages may tend to hollow out deep south-westerly grooves. At all events, the main Arctic return currents are very visible on the chart taking that direction, indicated by marked deflections of the isothermal lines. The most marked is the Labrador current, which passes down inside the Gulf Stream along the coast of Carolina and New Jersey, meeting it in the strange, abrupt "cold wall," dipping under it as it issues from the Gulf, coming to the surface again on the other side, and a portion of it actually passing under the Gulf Stream as a cold counter-current into the deeper part of the Gulf of Mexico.

50 or 60 miles from the west coast of Scotland, I believe the Gulf Stream forms another though a very mitigated "cold wall." In 1868, Dr. Carpenter and I investigated a very remarkable cold indraught into the channel between Shetland and Faroe. In a lecture on deep-sea climates, which was published in "Nature," in July last, I stated my belief that the current was entirely banked up in the Faroe channel by the Gulf Stream passing its gorge.

Since that time I have been led to suspect that a part of the Arctic water oozes down the Scottish coast much mixed, and sufficiently shallow to be affected throughout by solar radiation. About 60 or 70 miles from shore the isothermal lines have a slight but uniform deflection. Within that line types characteristic of the Scandinavian fauna are numerous, and in the course of many years' use of the towing net, I have never met with any of the Gulf Stream pteropods, or of the lovely Polycystinæ and Acanthometrinæ, which absolutely swarm beyond that limit. The differences in mean temperature between the east and west coasts of Scotland, amounting to between 1 deg. and 2 deg. Fahr., is also somewhat less than might have been expected.

There is another point which is worthy of consideration. It is often said that about the latitude 45 deg. N., the Gulf Stream thins out and disappears. The course of a warm current is traced farther on the maps, even to the coast of Norway and the North Cape, but this north-easterly extension is called the Gulf Stream drift, and is supposed to be a surface flow caused by the prevailing S. W. anti-trades. There seem to me to be several arguments against this view. The surface of the sea, at all events between 40 deg. and 55 deg. N., has a mean temperature higher than that of the air, and that could scarcely be the case unless there were a constant supply, independent of the wind, of water from a warmer source ; and any question is, to my mind, entirely set at rest by our establishment of the mass of warm water moving to the north-eastward, whose curves of excess of temperature, so far as they have as yet been ascertained, correspond entirely with those of the Gulf Stream.

I cannot at present enter at any length into the very fundamental question which has lately given rise to so much discussion, whether the Gulf Stream is actually the agent in conveying heat to the North Atlantic and ameliorating the climate of its north-eastern shores, or whether these results are not rather produced by a "general oceanic circulation."

As, however, I am frequently quoted by my friend and colleague in much scientific work, Dr. Carpenter, as holding an opinion different from his, and as my present remarks place my views beyond doubt, it may be well to give a reason for my want

of faith. Dr. Carpenter's view, if I understand him rightly, is that there is a great general convective circulation in the ocean, on the principle of a hot-water heating apparatus, and that the Gulf Stream is only a modified and partial cause of this general circulation. Now, in the first place, as I have already said, it seems to me that the distribution of warm water in the North Atlantic has been traced to its source, and all the general phenomena of the Gulf Stream, its origin, its course, its extension, and its depth at certain points, have been *proved* by the careful observations of many years, which I see no reason whatever to doubt. The constant impulse of the trade wind drives a broad current of equatorial water against the American coast. A great part of this current is observed to turn northwards through the Strait and round the islands, and to pour an eternal flood of hot water in a certain direction, under known laws, into the closed basin of the North Atlantic, and as a natural consequence the temperature is very considerably raised.

We are undoubtedly most deeply indebted to Dr. Carpenter for the forcible way in which he has brought forward the arguments on the other side; and, after carefully considering everything, I am thoroughly willing, with Sir John Herschel, to cede that "there is no refusing to admit that an oceanic circulation of some sort must arise from mere heat, cold, and evaporation as *veræ causæ;*" and that "henceforward the question of ocean currents will have to be studied under a twofold point of view;" but my strong conviction is that if the sagacious philosopher whose loss we now deplore, had been spared so to study it, he would have only been strengthened in his verdict of 1861 as to the Gulf Stream, that there can be no "possible ground for doubting that it owes its origin entirely to the trade-winds." Dr. Carpenter attributes the general oceanic circulation, of which he regards the Gulf Stream as only a modified case, to tropical heat and evaporation, and arctic cold, possibly aided by differences of barometric pressures; or to convection pure and simple, as illustrated in his experiments before the Royal Institution and the Geographical Society. Now, what we expect of Dr. Carpenter before we are called upon to accept to the full his magnificent generalization, is a calculation and demonstration of the amount of the effect of the causes upon which he depends acting under the special circumstances. We must remember that heat is received by the ocean at the surface only, and that owing to cold indraughts all over the globe, so far as we know, the temperature falls the deeper we go; that all our observations tend to show that the temperature of the sea is only influenced by direct solar radiation to any amount to the depth of 50 fathoms, so that all currents depending upon difference between equatorial and polar temperatures, must be produced and propagated in a film of water about the depth of the height of St. Paul's and 6,000 miles long. The black line bounding that chart represents pretty nearly the depth of the ocean, and even were the whole of the water supposed to be involved in the movement, it would be difficult to imagine a perceptible current to be produced in so thin and wide a sheet by such feeble cause. It would be impossible to indicate by the finest hair line the tenuity of the film which is actually affected by the direct rays of the sun. How differences in barometric pressure can produce constant currents I do not see. Rapid fluctuations in pressure in places within a short distance of one another, will doubtless produce readjustment by a wave motion; but constant differences of pressure will simply produce constant differences of level and no currents. Varying pressures at very distant points cannot possibly produce a constant current. I freely admit that I am quite incapable of undertaking the investigations which might lead to the estimation of the relative or actual importance of these causes of currents. I have several times put the question to specialists in such physical inquiries, but they have always said that it was a matter of the greatest difficulty, but that their impression was that the effects would be infinitesimal.

I fear, then, that, in opposition to the views of my distinguished colleague, I must repeat that I have seen as yet, no reason to modify the opinion which I have consistently held, that the remarkable conditions of climate on the coasts of Northern Europe are due in a broad sense solely to the Gulf Stream; that is to say, that while it would be madness to deny that in a great body of water at different temperatures, under varying barometric pressures,

and subject to the surface drifts of variable winds, currents of all kinds, variable and more or less permanent, must be set up; yet the influence of the great current which we call the Gulf Stream, the reflux in fact of the great equatorial current, is so paramount as to reduce all other causes to utter insignificance.

NITRO-GLYCERINE TEST.

From the St. Louis "Journal of Commerce."

A few days ago we announced the presence in the city of Dr. Carl W. Volney, the efficient and accomplished representative of the Lake Shore Nitro-Glycerine Company, of Painesville, Ohio, who had just finished the work of driving a tunnel through the hard lithographic limestone 300 ft., at Hannibal, to secure an approach to the new bridge. The result was that Dr. Volney was at once engaged to make a practical test for the Pilot Knob Company, and orders were given by President McCune that the proper arrangements be made, at either Pilot Knob or Shepherd Mountain, to give a severe test.

Mining being one of the specialties of the "Journal," our mining editor accompanied Dr. Volney to Pilot Knob, to witness the test, and is therefore able, as an eye-witness, to give the result. Two holes that had previously been drilled in solid iron ore for powder, say 2 in. in diameter and from 8 to 9 ft. deep, were used. The burthens of these were from 8 to 9 ft., and the iron ore was cleaned off, probably from 100 to 150 tons in each case, and the ore broken so small that block-holing or further reduction could be dispensed with. All who were present were greatly astonished with the result, and with the power of this great explosive.

But the most astonishing result was attained in blasting in the hard porphyry, where a hole had been drilled only 2 in. in diameter and 7 ft. deep, with a burthen of about 10 ft. The explosion was truly terrific! It not only broke off all the solid rock in front and on either side, but to a depth of 15 ft. below the hole, and shattered and loosened the previously solid rock some 6 or 8 ft. back of the hole, thus really cracking the rock in the rear and on both sides, in an area of probably 30 ft.

Hundreds of tons of rock and ore were thus thrown down by each of these explosions, proving satisfactorily that this is the most effective and powerful explosive agent ever used in this region.

The Arcadia House is fully 2 miles from the location where the test was made; yet Mr. Robinson, of the Arcadia Hotel, and several citizens of Ironton, state that they distinctly felt the shock of the explosion.

The holes used for these tests had been drilled for powder, and were not of proper proportions. Had they been drilled for this purpose, there should have been 12 or 15 ft. greater burthen—the holes should have been 20 to 30 ft. from the edge of the rock or iron.

Several points were satisfactorily decided: 1. That nitro-glycerine is at least 12 times more powerful than powder. 2. That one-half the drilling can be saved by its use. 3. That there is no ore or rock that cannot be moved by it. 4. That it can be handled with safety by those who understand it.

The Lake Shore Nitro-Glycerine Company, of Painesville, Ohio, have already used it successfully in driving the tunnel through at Hannibal, and in mining operations at Lake Superior during the past 2 years.

We have heretofore withheld our endorsement, because it has been considered very dangerous, either in transportation or in handling. But in the occasion before us, we notice that the ingredients of which this explosive is composed are kept entirely separate until they are needed for use, when they are brought together. Until this combination, there is no more danger than from the breaking of a can of nitric or sulphuric acid. Dr. Volney's plan is to erect a shed at the mines, remote from any other buildings, where small quantities can be prepared, and thus the risk and danger are avoided; and as he has used it probably more extensively than any other person in this country, and with greater success, we have confidence in the results as foreshadowed by him.

We anticipate as a result of this practical test, that our miners who have large masses of iron ore to blast, and railroad contractors, will be interested in employing this most powerful agency.

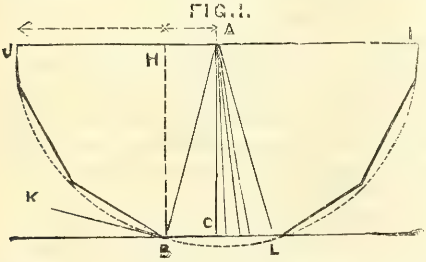
One feature that will be of interest is this: The nitro-glycerine can be graduated, so that a light charge will merely crack or loosen the rock, or break it into small pieces It is hardly necessary to say that the last charge, in the porphyry rock of Pilot Knob, was a large one, and that the result was the most astonishing of any ever made in this State.

TRACTION OF ROAD STEAMERS.

By L. WAGONER, C. E.

Permit me to call the attention of your readers to the August number of the current volume relating to the "bite" of elastic wheels. The position taken by the author of the article is, that the leverage obtained at the point B, Fig. 1, is one of the causes of the increased "bite." That it has nothing at all to do with it will be obvious upon inspection of the figure. The pressure upon each side of the point C is the same while at rest, and the position

FIG. 1.



taken by Mr. Todd, that "a certain amount of power must be applied at I great enough to raise the total weight on the wheel while turning at B," would be correct were it not for back pressure from C L. If the two forces are in equilibrio while at rest, they are the same while in motion ; and, therefore, the only changes that take place in an elastic wheel are two, viz.: the wheel is reduced in diameter by the depth of compression, and the weight is removed from the theoretical point of tangency and distributed over the compressed surface. The doctrine, that friction is independent of surface but proportional to pressure, only applies to surfaces of a moderate degree of smoothness, and in the case of the road steamers will not hold good at all. Were the bodies both smooth and elastic as rubber upon ice, the only difference that would ensue would be in the coefficient of friction of the substances in contact. In the case of the so-called smooth bodies in contact, the atoms must be in a plane or curved surface as near as practicable ; whereas, in the case of the road steamer, the surface of the track (road) is full of irregularities, and the wheels sinking into them, the tendency to slip must produce a shearing strain upon the wheel and track. And, finally, it will be seen by reference to experiments on the friction of vehicles, that extent of surface in contact does influence and increase the resistance to rolling loads.

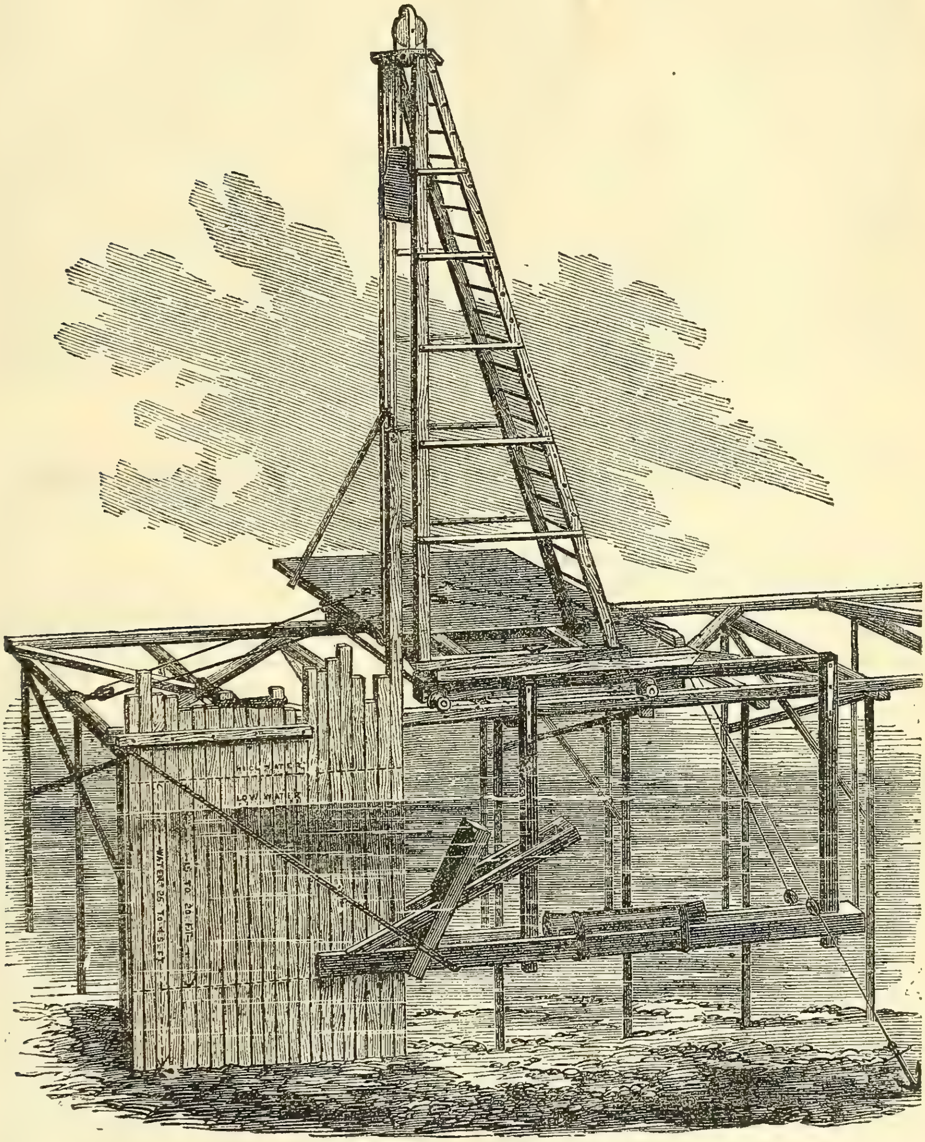
Lawrence, Kansas.

The whole of the ironwork upon the Southern Embankment is now being painted with the patent indestructible paint. If this paint really possesses the advantages claimed by its inventors of resisting the action of acids, and of sea water, as well as that of being nearly indestructible by time, the invention is a matter of almost national importance. One example of the paint has had a 3 years' trial, and has come out up to the present time triumphantly. The ironwork and lamp-posts of the Holborn Viaduct were originally painted with it, and even upon the parapets of the bridge the paint is still as fresh and well preserved as when first put on. When this is compared with the other paint upon iron, put on about the same date, the most striking difference will be at once seen.

The Chancellor of the Exchequer states that the ground plans of the New Courts of Justice have been prepared, and, he might say, completed. The plan of the elevation has been placed in the Library of the House, in order to invite the comments of honorable membeis upon it.

TOWLE'S "SPIDER" FOR DRIVING PILES IN DEEP WATER.

From "Engineering."



One of the most interesting exhibits of this class was a model of a "spider," designed by Mr. Hamilton E. Towle, and described by him on a recent occasion in the course of a paper upon the construction of the basin of the Pola Docks in the Adriatic. The object of this ingenious contrivance is to facilitate the operations of sinking sheet piles in deep water, and to insure their being fairly driven and kept in a true line. The spider consists of a framing suspended from the staging from which the piles are driven, by 2 vertical timbers, free to swing, and hinged at their lower ends to the horizontal bars that form the most important part of the

spider. These consist of 2 long timbers placed parallel to each other, and at such a distance apart that the piles to be driven may pass freely between them. The rear end is heavily weighted, and the forward end of the timbers, which are somewhat reduced in section, serve as jaws to embrace the sheet piles, a few of which it is necessary should be driven before the spider is put into operation. At a short distance from the end of the jaws a raking strut is secured between the horizontal timbers in such a way as to form a guide in driving the piles. It will be understood that the whole apparatus is free to swing upon the 2 vertical timber links attached to the staging, and ropes are attached to the front and rear of the horizontal timber to manipulate it. When brought into use, the forward hawser hauls upon the open jaws of the spider, until they embrace the sheet piles already driven, and the raking strut before mentioned is hard against the face of the outside pile. On a fresh pile being lowered, the end is engaged by the raking strut and timber forming a guide, until the point is brought up by the throat of the spider, which presses against the piles in position; when the falling weight is applied the spring in the hawser permits the apparatus to be driven back sufficiently to allow the passage of the pile, which is, however, kept perfectly in position until it is home. With an apparatus similar to the one now briefly described, the whole of the sheet piling at Pola was driven, under circumstances of peculiar difficulty, and the advantages of the arrangement were indisputably proved.

THE HALF-AND-HALF STYLE OF MODERN ARCHITECTURE.

From "The Building News."

If the present time is one in which public opinion on a variety of points is thoroughly unsettled, it is one in which public taste seems equally subject to change and uncertainty. There are a vast number of people who do not know their own minds about architecture, any more than about religion or politics; and their hesitation naturally expresses itself in the style which we have now to notice. It is less common in public buildings than in others, and least common of all in churches, which form so large a percentage of them. Its examples, too, are rarely of very great merit, and thus, from one cause or another, the selections from them which appear in the pages of an architectural journal give no criterion of their absolute abundance. They vary much in character, and it would be easy to put together a series in regular gradation, from Gothic designs containing a little Classic, down to Classic ones modified by a little Gothic. They are a symptom of transition, of dissatisfaction with existing types, of readiness to accept new ideas. They may possibly be steps on the road to another permanent system, but they can hardly be permanent themselves. The half-and-half style is too crude and disorganized to endure.

This fashion of mixing up the peculiarities of two or more past manners of building is often, as we have said, a symptom and result of dissatisfaction with all of them. It is felt that they all, more or less, fail to suit us; that in all there is much that we want to get rid of, while there may also be much that we would gladly, if possible, retain. This hybrid system of design, if taken at the best, is a sort of experiment: its followers may be looked on as inquiring whether it is practicable to keep the useful and reject the useless amongst the art-traditions of the past. "We admire," they may be supposed to say, "the massiveness, breadth, and grandeur of Greek and Roman work; but we see that Greek construction is unscientific, and Roman construction untruthful. We admit that both owed half their characteristics to a climate and a civilization different from ours; we are convinced that both can only be successfully imitated with the costliest kind of masonry and the highest finish of detail —that both, in short, are so expensive that we can rarely afford to do more than caricature them. On the other hand, we admire the skill and truthfulness of Gothic construction, the ease with which the pointed style adapts itself to circumstances, the freshness and naturalness of much of its ornament. But it, too, looks

unreal, if literally revived; its spirit is not the spirit of modern times; it tends to be fantastic, romantic, over-picturesque. We do not want to disguise our shops in middle-age costume, nor to put our warehouses into a sort of fancy ball dress; and we mean to try if the Classic simplicity of expression cannot be joined to Gothic honesty and naturalness of design." The aim seems plausible enough, and is, in fact, to a great extent a good one. The mistake lies in uniting the details of two styles, and supposing that this is the way to unit their spirit. What needs doing is something much more subtle and difficult than this, otherwise every pupil and office-boy might invent a new style. Still, these attempts, unsuccessful as most of them are, have something to teach. They often show where a change is wanted, though they seldom show exactly what that change should be. The details which they agree to reject, whether Gothic or Classic ones, are likely, though not certain, to be found in reality objectionable. They may, indeed, be set aside through prejudice, but it is equally probable that good cause exists for their disuse.

Of the Gothic details omitted in these hybrid structures, one of the most constant is the tracery window. Here, at least in civil and domestic work, the omission is a natural one. As long as the public prefer sashes to casements, so long, at least, will slender tracery be out of place. The horizontal lines of the sash are so marked that nothing but a solid pier or column will keep them in due subordination. Joined to the attenuated detail of the later Gothic, they catch the eye and rival the stone mullions in importance. They cut the light of the window most unpleasantly in two, and destroy the vertical tendency of the design. And apart from this, sash-frames make mullions plainly unnecessary. What need is there of stone work to support the glass, when that glass is already supported by wood? Mullions and tracery are a natural and reasonable thing while the glazing is actually attached to them. They divide the area into widths narrow enough to stiffen the lead lights and iron frames; they form the stone rebated frame border with which the casements close. But when, as in the sash, the glass is carried in a wooden frame, and this frame works up and down in a wooden border, the whole thing has been already effected. There is no purpose for mullions, except that of hiding the real construction; their occupation is gone—they are a superfluity, a sham. We see, therefore, no defensible ground for the use of thin mullions in connection with sashes, meaning by thin mullions those which merely divide lights of which several are included beneath a single arch, and which have no other purpose than thus to divide them. If they carry the wall above, or even a solid tympanum, the case is different. They have then a practical use to serve; they become, in fact, small piers or columns, and are mullions no longer. The mixed style of the last few years has thus, we think, done rightly in rejecting tracery where sashes are used; but it has not been happy in finding a substitute. Its only idea, in the great majority of cases, has been that of a round-headed aperture, very broad, very low, and very ugly. Is there, then, some transcendent virtue in a wide semi-circular sash, which totally outweighs all considerations of beauty? Every one knows, on the contrary, that nothing can well be worse. Its upper part is so rickety and troublesome to close that it has even become the custom to make it square inside, though it appears round without. It really seems as if this dumpy meeting-house window had its ugliness tolerated for the sake of its inconvenience; it is hard, at any rate, to see why else it is endured and perpetuated.

Take another Gothic feature which this style omits, the arch moulding. In a brick building, and many of the buildings in question are of brick, elaborate mouldings are somewhat out of place. To be true in curvature they must usually be rubbed, not formed in the clay before it is burnt; and they thus become too costly for common work. They are replaced, in a great deal of this hybrid architecture, by colored voussoirs and patterns; and only in a minority of cases with a good result. These patterns, it is true, while they are fresh and bright, contribute something to the showiness of the design. They give importance, for a time, to the arches; but they do this in a far less satisfactory way than the details which they replace. They do not repeat the beautiful curves of the window-head, and enhance their beauty by delicate gradations of light and shade; they are totally dis-

connected forms—patches of applied surface decoration—not decorated features of construction. The result is that the eye soon wearies of them. Their effect, perhaps, is not in all cases to be rejected; we may be willing now and then to adopt them as part of the architect's *repertoire;* but we shall do ill to accept them as a final and complete substitute for the magnificent arch-moulds of the Early Pointed period; and even such excellence as they possess they do not long retain. In our towns, at least, they fade before their designer's eyes, and in a very few years disappear entirely behind a veil of soot. After all, an arch recessed in square orders is a far more permanent and far more architectural production. If we cannot have mouldings, we can, at least, have a series of square arrises; we can have lines of shadow and contrasting lights—something to express solidity and thickness, rather than a mere surface coating of red and yellow.

Another Gothic feature abandoned by this eclectic school is the high-pitched roof. For this there may be several motives, of which a chief one seems to be the saving of thought and invention. Steep roofs cannot well have very wide spans, or they rise too high, present too much surface to the wind, and look awkward and unwieldly. Now, while it requires care and skill to cover a large area by means of several moderate-sized roofs, anybody can manage it within reasonable limits in a single span. All that is necessary is to look in Tredgold's "Carpentry," or some similar book, for the form and scantling of the trusses, to stretch them across from wall to wall, to fix on them the usual apparatus of purlins and rafters, and to finish off with the usual pyramid of slating appropriate to what is known as a "substantial family residence." It is true that by a little contrivance the trusses might have been dispensed with, and a far better house built for somewhat less money; but as the proprietor is satisfied with it as it is, this is a matter which concerns no one. Another thing which has kept the flat-pitch in favor is doubtless the idea that there must be a waste of room where the angle is steeper. On one supposition, indeed, this must undoubtedly be the case, if it is an absolute necessity that all rooms should have horizontal ceilings. If a level surface of plaster overhead is really a first requisite of civilized life, then, indeed, the inside of every roof must be chiefly wasted, and it is natural to keep all roofs as low as may be. But if, on the contrary, it is a relief rather than an annoyance to escape from the box-like cells in which we pass our days into any apartment which has a structural and distinctive form, then there is no reason why some of the pleasantest chambers in the house should not occupy the space which is now neglected. We can easily make the construction fire-proof; we can render it as impervious to heat and cold as any part of the dwelling; and so far the high-pitched roof has more advantages for us than it had even for those who first introduced it. But it is not always for practical reasons, either real or supposed, that this feature is set aside. Quite as as often its exclusion seems to be only one part of a system—one development of the general idea on which the designers of the half-and-half style act. Their aim—or that, at least, of many of them—seems to be the production of a horizontal style free from the untruthfulness of the modern Classic, and their low roofs, like many other of their details, are adopted simply because their character is a horizontal one. This general aim, then, even more than the separate details, is what needs to be examined. Ought our modern style to have a strongly marked horizontal character? If not, the members of the school in question are on the wrong tack; for it is precisely this character which they seek to retain, while working to a considerable extent on mediæval principles. Without indorsing their practice, it is easy to feel a certain amount of sympathy for it. Remembering the absurd and exaggerated verticality which some quasi-Gothic designers of the day affect, large allowance should be made for the inevitable reaction. Looking, for instance, at the "Decorated" chapel of the period, with its wiry buttresses and pinnacles, and gablets all running up to seed, one cannot be very severe on the men who say, "Come what may, we will keep clear of such frippery as this; our buildings, good or bad, shall look like buildings, and not like confectionery ornaments on a Twelfth-cake." It is enough, for the moment, to make all verticality an abomination, and to drive us into an approval of heavy entablatures, and vast, overshadow-

ing eaves. But reason shows a way between the two. On the one hand, our town architecture must, by its nature, have a considerable number of horizontal lines. The mere division of houses into separate floors is of itself enough to produce them. There will inevitably be level ranges of windows, tier over tier, and to make them look like long vertical openings would be both untrue and unsatisfactory. Keep, then, those horizontal features for which there is a reason; display them as far as they exist; but do not add others which have neither purpose nor reality. The enormous cornice, for instance, which projects from the wall near the top of these mongrel structures, is quite uncalled for and unnecessary. It is not even an eaves cornice; it is a thing stuck against the parapet with no legitimate excuse whatever. Far better show the real construction, here as elsewhere; let the parapet announce itself, if there is a parapet, and decorate it instead of concealing it. Let the roof and the chimneys show themselves, and since their tendency is a vertical one, let it appear so. The very habits and customs of English society point to picturesqueness in our streets. We cannot have uniformity, for uniformity implies minute rules and regulations which would not be tolerated in this country for a moment. We cannot carry out the horizontal principle as the main one in our street architecture, with any success, until everyone is bound to build with stories of the same height, with cornices of the same section, with roofs of the same pitch, with doors and windows, even, of the same, or a closely similar pattern.

Till all this is enforced by law, every frontage must take care of itself; and the only choice is to give it a picturesque sky-line or a flat one. Now nothing is less interesting, has less merit of any kind, than a row of flat-topped house fronts of all sorts of heights and sizes, bobbing up and down, and looking as if they ought to have been uniform, but could not manage it. The most Classic of Classic architects cannot admire them as a whole, for they spoil each other; few things are more offensive than an attempt at regularity which does not succeed. If we could keep our street fronts as even as a line of the Guards on parade, it might, or might not be well to do so; but since we can get them in no better trim than Falstaff's ragged regiment, the only course is to break them out of order at once. Affecting no regularity, they may easily become picturesque; all that is wanted to this end is to let them follow their nature. And so, fully agreeing that a very vertical style is not the style for our towns, we are equally sure that an affectedly horizontal one is out of place there. The true medium will be found by keeping close to realities, by letting ranges of windows run straight when there is floor above floor compelling them to do so, but by allowing the roofs to break into hips or gables or dormers, just as may be most convenient and most beautiful.

We might go on to any extent criticising the other details which are retained or omitted in this composite manner of building, and might point out, if they really need pointing out to any one, the glaring discords which are produced by mixing up the peculiarities of two opposite architectural systems. But believing the general principle involved to be a mistake, there is no need to insist further on subordinate questions. The great want for modern purposes, as we conceive, is not a style whose leading features are rigidly uniform and horizontal, however much liberty such a style may allow in minor details. It is rather one which is picturesque by nature, though it submits to restraint where restraint is necessary—one which follows and expresses the actual character of the buildings to which it is applied, being horizontal where they are horizontal, and vertical where they are vertical. And it is likely to be arrived at, not by mixing up two quite distinct and incongruous types, but by selecting that one which seems most nearly to fulfil the conditions, and modifying it gradually and thoughtfully in the required direction. Hybrid races are rarely permanent, and the hybrid style of our modern buildings is not likely to prove an exception to the rule.

Street Railways in Melbourne. — An application has been made to the Melbourne City Council, by Mr. M'Millan, for authority to introduce street tramways into that city. The matter was referred to the Public Works Committee of the Council.

THE KEOKUK AND HAMILTON BRIDGE OVER THE MISSISSIPPI RIVER AT KEOKUK, IOWA.

From the "Journal of the Franklin Institute."

STATEMENT OF THE PUBLIC TEST OF THE STRUCTURE.

This bridge was tested May 18, 1871, for Mr. J. Edgar Thompson, President of the Pennsylvania Railroad Company. The tests were made under the direction of Mr. Henry Pettit, Civil Engineer, Construction Department, Pennsylvania Railroad, and all facilities for making them satisfactory were kindly furnished by Mr. George S. Smith, the engineer of the bridge, resident at Keokuk, who has had charge of the work at the bridge site from its commencement to its successful completion.

The designs for the superstructure were furnished by Mr. J. H. Linville, C. E., the drawings being carefully worked up under the direction of Mr. M. Benner, at Pittsburgh. The superstructure was made and erected by the Keystone Bridge Company, of Pittsburgh.

Commencing at the west or Keokuk end of the bridge, the spans are located as follows: Pivot span, total length of one truss, centre to centre of end posts, 376 ft. 5 in.; opening under each arm of 160 ft. measured on the square ; 2 spans, 253 ft. 6 in.; 8 spans varying in length from 148 ft. $4\frac{3}{16}$ in. to 161 ft. 7 in.; total length, back-wall to back-wall on bridge seats, 2,192 ft. It is a through bridge built on a skew of 17 deg. 15 min., with a distance between the two trusses of 21 ft. 6 in. It carries a single line of railway track and two tramways for local traffic, the track being placed in the centre, between the tramways. On each side of the bridge, outside of the trusses, are foot-walks, 5 ft. wide, protected by light and substantial iron lattice railings.

When making the test the level and rod were in charge of Mr. E. H. Worrall, Engineer of the section work, and Major A. H. Burnham, U. S. A., Engineer in local charge of the Des Moines Rapids Improvements of the Mississippi River near Keokuk.

The load used in making the tests was a train made up of five engines from the Des Moines Valley Railway, with their tanks and boxes full.

The following table shows the composition of this train.

ENGINES.	Total length engine and tender.	Weight of tender.	Weight of engine.	Total weight.
	ft. in.	tons.	tons.	tons.
No. 1	39 0	16	26	44
" 19	41 7	20	31½	51½
" 22	42 5	20	31½	51½
" 20	41 7	20	31½	51½
" 3	40 5	18	27	45
Totals	205 0	....	....	243½

This load was placed so as to cover one-quarter of the span, when the deflections of the span were taken at the centre and quarter distances. The span was then loaded ½ of its length, then ¾, and finally its entire length. The deflections being taken each time at the same three points. Afterwards the permanent set was observed. All the lengths of spans given are the distances from centre to centre of the end posts.

Pivot span (the largest yet constructed.)

Total length of one truss............376 ft. 5 in.
Arched upper chord. Depth of truss over drum........................ 35 " 0 "
Depth of truss at ends............... 27 " 9 "

Load of 95.5 tons on the east half of the east arm = 1.07 tons per foot lineal.

East arm of span.

Deflection of the east half............ .1-8 in.
" at the centre.................15-32 "
" of the west half............. 3-32 "

West arm of span.

Deflection of the east half	3-32 in.
Rise of the centre	3-32 "
" of the west half	3-64 "

Load of 178.5 tons covering entirely the east arm = 1 ton per foot lineal.

East arm of span.

Deflection of the east half	23-32 in.
" at the centre	15-16 "
" of the west half	23-32 "

West arm of span.

Rise of the east half	
" at the centre	
" of the west half	
Strain of compression at centre chord of east arm	
Strain of tension at centre of east arm	

Load of 103 ton ... 96.5 tons on the wes ... per foot lineal.

East arm

Deflection	23-32 in.

We

Def	15-32 in.

... after all load was re-

	1-80 in.
	1-27 "
half (next the drum)	1-16 "

West arm.

East half (next the drum)	5-32 in.
Centre	1-80 "
West half	1-27 "

Time of turning the pivet the entire opening of $72\frac{3}{4}$ deg.

With the engine	2 minutes.
With six men	2 min. 30 sec.

Span No. 3.

Length 253 ft. 6 in. Height of truss 27 ft.

Ratio of height to length = 1 to 9.388.

Load of 68 tons on the east quarter = 1.07 tons per foot lineal.

Deflection of the east half	5-32 in.
" at the centre	1-8 "
" of the west half	1-27 "

Load of 147 tons on the east half of span=1.16 tons per foot lineal.

Deflection of the east half	19-32 in.
" at the centre	25-32 "
" of the west half	13-32 "

Load of 198.5 tons on the east three-quarters of span = 1.04 tons per foot lineal.

Deflection of the east half	31-32 in.
" at the centre	1 3-8 "
" of the west half	29-32 "

Spread of low ... at the roller box = ...

Load ov ... 243.5 tons = .96 to ...

Deflect	1 5-32 in.
	1 11-16 "
half	1 1-4 "

... wer chord measured at ... in.

... entre of upper chord, com- ... 8,962 lbs. per sq. in.

... at centre of lower chord, tension ... 51 lbs. per sq. in.

Span No. 2.

Length 253 ft. 6 in. Height of truss, 27 ft.

Load 243.5 tons over the centre span =96 tons per ft. lineal.

Deflection at the centre of span = $1\frac{3}{4}$ in.

Permanent set after load was removed 3-64 in.

Span No. 4.

Length 159 ft. $9\frac{1}{8}$ in. Height of truss 21 ft.

Ratio of height to length, 1 to 7.6.

Load of 44 tons on the east quarter = 1.1 tons per foot lineal.

Deflection of the east half	9-32 in.
" at the centre	5-16 "
" of the west half	19.32 "

Load of 95.5 tons on the east half= 1.19 tons per foot lineal.

Deflection of the east half	7-16 in.
" at the centre	23-32 "
" of the west half	7-8 "

Load of 147 tons on the east three quarters of span = 1.22 tons per foot lineal.

Deflection of east half	2-8 in.
" at the centre	1 "
" of the west half	1 3-6"

Load of 153 tons over the entire span =905 tons per foot lineal.

Deflection of the east half	25-32 in.
" at the centre	1 5-32 "
" of the west half	1 5-16 "

Permanent set after the load was removed at the centre of span = $\frac{1}{4}$ in.

The "Observer" contradicts the rumor that there is an idea of placing the Mint on the Thames Embankment. The site which the Government proposes to adopt for a new Mint is, it states, in Temple-lane.

THE TIMBERING OF TRENCHES AND TUNNELS APPLICABLE TO RAILWAY AND SEWERAGE WORKS.*

From "The Engineer."

Timber is required in constructing sewerage works, to support the sides of the narrow and deep cuttings required in building the drainage culverts and pipe drains, for centring, drainage purposes, and other special purposes hereafter mentioned. It is also required in tunnelling to support the sides of the shafts, and the roofs, and side walls of the headings; to carry the tramways, and for the construction of the long pump rods in the deep shafts. Also for centring, drainage, trunks, and other special purposes. The manner of framing and introducing the timber depends greatly upon whether the timbering is to be only temporary, that is to say, merely to support the ground in advance of the masonry, or whether, as in the case of headings for a tunnel, it is required to stand possibly for several years.

Secondly, on the description and quality of the timber to be used; *i. e.*, whether the timber is to be round, half round, or squared timber; and what sort of timber and what sizes of it are available. It is usual for temporary work, such as that first mentioned, to use the timber that is the cheapest, the most easily and most economically transported, and which is the most salable after it has served the temporary purpose required of it. If the timber is sufficiently good and strong for its work, no objection can be taken to such a course, but it is often a very short-sighted policy, as it is hoped to be shown presently. Before entering more particularly into a description of the timbering required for open cuttings for sewerage works, and for driftways, headings, etc., for railway tunnels, it will be well to set forth a few simple rules for carrying out such works of timbering generally. They are well known by all mining engineers, and most of them by any good practical miner. (1) All timber used should be of as hard and tough a nature as it is possible to procure for a reasonable cost. (2) All timber should be cut at the fall of the year, when the sap is down, and no timber ought to be used that has not had a certain amount of seasoning, having been kept either constantly wet or dry for not less than six months after it was felled. (3) All timber used should have been barked three months before using. (4) The best description of timber for shores, sills, posts, etc., is larch or fir; oak may be used occasionally to resist a great transverse strain. (5) The principal strain should in all cases be thrown as far as possible upon the end grain of the timber, or, in the case of waling pieces, sills, or sleepers, which should always, if possible, be of half round timber upon the rounded side of the timber. (6) All side pillars or side posts should be slightly oblique, forming with the head and ground sills the section of a truncated pyramid. The tenons of the pillars, etc., should be cut square, and the mortices in the sills at an angle to prevent lateral movement. (7) The timbers should be framed and fitted accurately; no spikes or bolts to be used to keep the timbers together; all wedging up to be avoided as far as possible, except in certain cases described hereafter. (8) All polling boards in headings, and the linings at the back of the curbs where square shafts are timber-lined, should be pointed and driven obliquely, each set to overlap the preceding one. (9) All shores to be fitted to drive from above, and never in any case sideways or horizontally. When half round timber is used for the waling, the ends of the shores to be slightly bird's-mouthed, to fit to the shape of the timber. (10) As large a bearing surface as possible to be allowed where the end of one timber takes a bearing upon the face of another timber. (11) When planks, battens, or other square timbers are used for waling pieces, they should be bedded in the sides of the excavation at a slight angle, so that when the shore, cut to the proper angle, is driven down from above, it will always take a fair bearing over the whole of its surface. (12) Adjustable gauges to be provided for taking the exact length and exact angle of ends of the timber required. (13) No timbers require to be fitted in their places more tightly than to take a fair bearing. If any strain is shown

* Paper read before the Society of Engineers, by Mr. CHARLES TURNER, of Southampton.

upon them they will be tightened far better and more in the direction required than by any artificial means that can possibly be used.

First, as to timber in open cuttings or for sewerage work. Most of these works are executed either in large towns or in the neighborhood of them, and the timber used to support the sides of the excavations is either such as can be found in the place or can be most easily conveyed to it—fir scaffold poles, cut up into lengths, being used for the shores, and the cheapest description of battens or planks that can be procured, for the walings. In many cases these are only used for form's sake, and might readily be dispensed with. The common practice is to introduce tiers of battens, about 4 ft. or 5 ft. apart in depth, with round poles of from 4 in. to 6 in. diameter for shores. These are almost always driven sideways into their places, and even if well cut and fitted have but a comparatively small bearing upon the batten which forms the waling piece. If the cutting is dry, these shores frequently become loose and drop down, as there is seldom any upright or support under them. In many cases this arrangement proves sufficient, as no timbering is really wanted ; but when there is really a pressure exerted against the timber, the waling planks or battens are very apt to split, from the shores being driven in sideways, and therefore bearing on a very small surface of the timber. If battens are used in the above manner it is much better to cut the excavation to a slight batter, and to let the battens or planks in parallel to the face, and to drive down the shores from above sufficiently tight to give the batten a firm bearing against the sides of the excavation. The lower tier of battens should be strutted up from the ground, and uprights should be placed at intervals between the tiers of battens, especially under the joints. When half-round timber can be procured it is generally preferable to the battens, as it has less tendency to split. In that case the flat side of the timber should be placed against the side of the cutting and slightly let into it, and the end of the shores should be slightly bird's-mouthed out to fit the round side of the timber, and should be driven down from above. If the ground worked through is of a very shifting nature, such as thin strata of sand or clay, with water, it is often necessary to close-timber the cutting. In this case planks should be placed upright at intervals of from 5 ft. to 6 ft., with horizontal planks behind them, one upon the other; the usual round shores being introduced between the planks, which must always be laid at a slight angle, so that by driving down the shores from above the whole will be wedged firmly into its position. When the ground is very insecure, the upright planks can only be driven in short lengths, the one being made to overlap the other. Of course a system of timbering comparatively so complicated should not be used unless absolutely necessary, and in many cases where there is sufficient depth of roof it is better to carry on the excavation in short lengths and tunnel in between. But there are cases where tunnelling cannot be adopted, and it is better to go to any reasonable expense in timbering rather than to risk life. Besides the above reasons, in many instances it is absolutely necessary to leave the timber in until the ground has become thoroughly consolidated. Unless such timbers are of the proper size, and have been well framed together, such a precaution is worse than useless, and it gives a fancied security which does not really exist.

There is another use of timber, which cannot be said to be confined strictly to cutting trenches for sewerage work, as it is applicable in all cases where masonry is carried on in deep excavations. It has been found more advantageous, instead of carrying down the mortar in hods to supply the bricklayers, to construct small trunks $5\frac{1}{2}$ in. sq. internally and about $\frac{3}{4}$ in. thick; they are made out of stuff procured by putting two cuts through a batten, and fitted with hopper heads. The lower ends are easily shifted, so as to deliver on to the mortar boards, the trunk being slung by a rope attached to short shear legs across the cutting. The mortar heap is made close by the cutting as the work proceeds, and one man filling the mortar into the hopper heads of 2 trunks can keep 4 bricklayers going instead of 2, or even at times 3, hodmen, who would otherwise be required, temporary shores and struts being used in some cases until the permanent shores can be driven. Where the ground is of the nature of running sand, and can only be excavated

in very shallow lifts or stages, the excavation may be carried on after the manner in which square shafts are sunk and timbered in some of the German brown coal mines, upright pieces of half-round timber, pointed at the ends, being first driven into the ground, in advance of the excavation, and inclining slightly inwards. Waling planks are fixed between these timbers, and supported in a temporary manner by short piles, until the shores are introduced and driven from above, as before mentioned, care being taken always to have uprights under the waling planks. A space, varying in width from 2 in. to 3 in., will be left behind the waling planks, into which should be driven planks, or battens, or half-round pieces of timber pointed at the ends, and which pieces must be gradually driven downwards as the work proceeds, as far as safety will allow, when another upright is driven down in front of the first in the same manner as already described, and shown in sinking short lifts through shifting ground, requiring to be close-timbered. Great additional strength is given to this mode of timbering by introducing long binders of stronger timber from top to bottom of the excavation, taking a bearing against all the walings and having independent shores between them. This plan has also a great advantage in deep cuttings, where lias stone lime is used. The sliding of the mortar down the trunk keeps it chafed up and soft, instead of its constantly getting stiff upon the mortar boards when carried down in hods. It is of such great importance that the timbers used in shoring should be accurately fitted, that simple adjustable gauges, which do not easily get out of order, will always pay for themselves, such as may be made for taking angles and splays, and also for taking dead lengths at the same time. Although there are great objections to using iron bolts, screws, or spikes, to frame shoring together, there are cases where iron may be advantageously used in connection with wood, where shores have to be taken down and replaced on the completion of each length of culvert. The ends quickly wear out, especially if they are driven horizontally, and the shores become too short. The plan was tried of shrinking iron hoops on to the ends of the shores, and was found to answer very well, and that there was a saving of one-third of the timber used in shores, even in a length of 100 yards of culvert. Where the pressure is very great upon the shores they are very apt to split the waling, unless they are cut very accurately and are of the full size of the plank. It has been found of advantage to provide a few wrought-iron clamps to use in such exceptional cases; they are fixed at the back of the shores. There is one more way in which iron may be used with advantage in connection with timber for shoring. It is frequently necessary to introduce additional shores at the bottom of a deep excavation for sewerage work, or to change the position of those which are fixed, to make room for the masonry. It is often very difficult to drive such additional shores into position, so that the proper pressure may be thrown upon them without disturbing several others. It is proposed to effect this object by making use of a double shore capable of adjustment in the length, and constructed in the following manner: A piece of round timber 7 in. in diameter, is hooped at both ends with strong wrought-iron hoops, made from $\frac{3}{8}$ iron 4 in. broad. A groove is then cut down the centre of the piece of timber 1 in. wide, as far as the hoops at each end, with 2 cross grooves in the centre $\frac{1}{2}$ by $\frac{1}{4}$. Folding wrought-iron wedges, with projecting ribs to fit the cross grooves, are then introduced in the centre, and driven up till the timber is sprung apart about 2 in. or more, as the case may be, according to the length of the shore. Two other rings made of the same sized iron are then slipped over the ends of the timber, sufficiently large to go nearly as far as the centre wedges. They are to be driven sufficiently tight to hold them firmly in their positions; the shore is then ready to fix in place. When in place the wedges are to be slackened, and the spring of the timber will cause the shore to fix itself tight without any hammering or wedging. When so fixed, the loose rings are to be driven up against the wedges in order to prevent springing if an unusual strain is thrown upon the end of the shore. When the shore requires to be withdrawn, the wedges are to be driven up again, and in so doing the loose rings are driven back, and the shore being shortened is easily removed. Cast-iron friction rollers working on wrought-iron pins are sometimes introduced with ad-

vantage at intervals, instead of the wood rounds to the ladders used for conveying materials in deep sewerage trenches; they should of course be rather larger than the rounds. By carrying an endless rope round these rollers bricks may sometimes with advantage be lowered down in boxes, instead of being carried down in hods. There are many other minor uses for timber for sewerage work, such as centring, put together in pieces when common centring cannot be withdrawn, temporary drainage trunks, and other items, which need not be particularly described.

Secondly, as to the use of timber in tunnel headings. The timbering, when the ground is tolerably firm, generally consists of 2 side posts, which are let 4 in. or 5 in. into the bottom. They should be inclined towards each other and framed into a head sill. When the ground is soft or shifting, the side posts should stand on sole plates of half-round timber, or short pieces of plank about 1 ft. 6 in. long. If it is of a still more shifting nature, it is better to frame the posts into ground sills, either let into the bottom or framed together in a complete system of longitudinal and cross sills. When 2 sets of frames have been introduced at distances of from 4 ft. to 6 ft. apart, as the case may be, they are lined at the back with boards or planks, either at intervals or close together, as may be required. Pieces of board, pointed at the end, commonly called staves, are then driven above the head sill in the direction of the next frame; these should always be driven with a certain divergence outward, in order to make room for the introduction of the following set. This divergence is obtained either by cutting the board wedge-shaped, or by driving in slight temporary keys from the front between the boards and the head sill; or, better still, by introducing a lintel above the head sill, which is wedged up by two or more hard wood wedges against the ends of the boards. It is sometimes necessary to drive these boards also at the back of the side posts and under the sills, forming a close timbering, having the section of the frustrum of a pyramid. It is often also advisable, in order to assist in obtaining this divergence, to fix a third set of framing, rather larger than the others, in front of the second set, over or outside of which the boards are driven. The second set of staves is driven forward, in like manner overlapping the others to the extent of 5 in. to 6 in. If the stratum contains much water, it is necessary to secure the face as the work proceeds. It is better in that case to proceed in steps by fixing short planks against the face of the work, and driving shores between them and the next frame, and if necessary, strutting the frame against the one behind it. The poling boards and the boards forming the lining behind the side posts are then driven forward by degrees, sometimes only a few inches in the course of a day. Various temporary means of strutting and shoring the face are adopted, but these are so numerous, according to circumstances, that it is impossible to give any general rules for constructing them. Experience and presence of mind are the principal guides to be relied on in such cases. Where it is necessary to carry a tramway through the heading, the sleepers should be laid independently of the ground sills. The drainage from a heading should be carried in wood trunks laid upon the ground sills, and under the cross sleepers carrying the tramways. These trunks should be made with a bottom and two sides tied together by cross pieces, dovetailed into the sides of all the joints and intermediate ties, about 4 ft. apart. The top should be loose, formed of short pieces with ledges under, of such a length that they may drop easily into their places, and may be lifted for the purpose of cleaning out the trunk.

In enlarging the tunnel from the section of the heading to the full size, very little timbering is required in an ordinary way beyond the centring, as the masonry in all cases should immediately follow the excavation as it proceeds. There is always, however, a certain space to support in advance of the centring, to allow room for the men to work in. This will often carry itself; at other times it is supported by short ends of boards, or planks resting on the masonry, and either shored or strutted against the face. A better plan would be to make use of an inner and outer centring, the outer slightly overlapping the inner, and being strutted up from it. The front face of the inner or principal centring should stand almost fair with the face of the outer centring,

but must not overlap it much, in order to give room for filling in round the outside of the arch. The two sets of centring should be moved forward gradually as the work proceeds, and wedged up when in their places. The uprights should be of round timber; all tightening up should be done with wedges driven between the double plates. In some cases it is very desirable to construct the centring so that it may be taken to pieces. A trussed centring in 3 thicknesses is the most convenient description of centring for this purpose. The outside segments of the centring are cut in the usual form, and are jointed on the uprights; the uprights are shouldered to support the middle piece. The uprights and segments are tied together by wrought-iron loops, which are riveted to the one segment, and, passing through a mortice in the middle segment and the outside segment on the other side, or the opposite upright, are keyed firmly against the upright or opposite segment by a hard wood wedge driven through the loop.

Then as to timber in shafts. In some cases a double curb of 3 in. plank, with the cross joints properly broken, is laid upon the ground, and, the masonry being built upon it, it is gradually sunk into the ground, by excavating out the inside, and under the curb; various descriptions of iron bond being used to tie the masonry. For smaller shafts, a common well curb is used, rather more strongly constructed than usual. Where timber is plentiful, and the conveyance of materials difficult and expensive, a square or rectangular shaft may be sunk, and timbered in a similar manner to the shafts adapted for the mines in the Hartz Mountains. A strong curb of round timber is first laid, the timbers being halved together and slightly bird's-mouthed, in order that they may fit to the rounded sides. When the ground is very full of water, or otherwise insecure, the curbs are laid one upon the other. At other times they are kept at variable distances apart, and are sometimes lined at the back with 2 in. planks, but generally they are lined at the back with boards pointed at the ends, driven to a certain batter by the same means reversed as those described for driving headings, one set of boards always overlapping the next.

The long pump rods for deep shafts are generally of square timber, scarfed and bolted together, but where tapering sticks of round timber are readily available they will make an equally strong and much lighter and more economical pump rod. There are many other purposes for which timber is used in connection with tunnelling, as, for instance, the windlasses and horse whims for raising the stuff excavated, the ribbles or tubs in which it is raised, and the various timber erections and other buildings which are required in connection with the pumping and hoisting apparatus. These, however, vary so much that it would not be possible to describe them properly within the limits of an essay. It is sufficient to say that all framing should be well and strongly put together, and well tied with iron where it is in the open air, and all wearing parts should be of iron, or, if that is not possible, of very hard wood ; and nothing should be so complicated as to prevent an intelligent miner from taking it apart and putting it together again. It is not for a moment supposed that anything new has been brought forward in the foregoing observations. An attempt has only been made to collect together a few memoranda from personal experience as a railway and sewerage engineer and contractor, and also the results of the information obtained while superintending some mines and furnaces in the Hartz Mountains, the timbering of which was carried out under the direction of a very intelligent and experienced German mining captain. Several of the modes of using timber above described were there executed under his superintendence at the suggestion of the author of this paper.

We hear the Prussians are about to abandon the needle-gun, and are apparently hesitating between the choice of the Chassepot, of which they have half a million taken from the French, and the Werder rifle.

The Select Committee on Steam Boiler Explosions, of which Mr. Hick, the member for Bolton, was chairman, the "Post" has reason to believe, reported by a considerable majority against official inspection.

THE EAST RIVER BRIDGE.

SECOND ANNUAL REPORT OF THE CHIEF ENGINEER (COL. WASHINGTON A. ROEBLING) OF THE NEW YORK BRIDGE COMPANY.

To the Hon. Henry G. Murphy, *President:*

Sir,—I have the honor to present the following report of operations on the East River Bridge during the past year:

At the date of the last annual report, made June 5, 1870, the first foundation stone had been laid on the Brooklyn caisson, which was still afloat at the time, rising and falling with the tide. During the year that has elapsed the foundation of the Brooklyn tower has been successfully completed, notwithstanding numerous drawbacks, the caisson being sunk to a depth of 45 ft. below high water. The tower masonry is now being carried up, and has reached a height of 25 ft. above high tide.

The first material was brought up from the caisson by dredgers, July 5. By December 18, it rested upon 72 brick piers which had been built for its reception within the air chamber. The filling up of the air chamber required two months and a half, being finally closed March the 11th, nearly one month of which time was consumed in repairing the damages to the caisson caused by the fire of December 2, 1870.

The laying of masonry practically ceased in the middle of December, a rigorous winter forbidding its resumption until the middle of March.

Inasmuch as the Brooklyn caisson is by far the largest structure of its kind ever sunk, although not the deepest, and since the bulk of the material encountered was next to solid rock in difficulty of removal, it may be of general as well as professional interest to enter into a more detailed account of the operations.

EXCAVATION OF MATERIAL.

While the caisson was still rising and falling with the tide, the hours of work inside the air chamber were confined to low water. Three courses of masonry were required to weigh it down permanently against the buoyant effect of the inflated air chamber. The force of workmen inside was gradually increased, their principal occupation being the removal of sharp-pointed projecting boulders, which threatened to damage the supporting frames and edges of the caisson, as the latter settled down on them with a crushing force at low water.

Although the preliminary dredging had arrived at an uniform level of 18 ft. below high water, it was found that there were enough boulders overlooked to reduce this level to $16\frac{1}{2}$ ft. Several weeks were spent in removing them and levelling off the ground under the shoes to the 18 ft. level before the excavating machinery was ready to operate. In the pits under the water-shafts were several large boulders below the water level, upon which the lower edge of the water shafts rested. These were a source of considerable anxiety until removed by the tedious operation of clipping them to pieces with long steel bars.

The material now became sufficiently exposed to enable us to arrive at the conclusion that it was of a very formidable nature, and could only be removed by slow, tedious, and persistent efforts. This had indeed been the expectation from our previous experience in the dredging and blasting under water. But the work being under water, and, therefore, out of sight, did not impress us so much at the time, as now, when we were face to face with it.

NATURE OF MATERIAL.

In the two middle chambers of the caisson the ground was composed of trap boulders, large and small, packed together so closely as to touch, the space between being filled by a natural concrete, composed of decomposed fragments of green serpentine rock. The boulders were coated with this natural cement, which adhered so strongly as to defy the action of steel wedges. A steel-pointed pick had no effect whatever. It was only by using a steel-pointed crowbar, and driving it in the crevices with heavy sledges, that any of this material could be piled up and removed. In chambers Nos. 1 and 2 adjoining the Fulton Ferry slips, the boulders were equally as large and as numerous, but the cementing material was clay and gravel, not so hard as the serpentine concrete. In chambers Nos. 5 and 6, however, this hard ridge rapidly fell away, giving place to several feet of mud, under-

laid by a stratum of unctuous blue clay, and continuing soft in the north corner of No. 6 chamber for a depth of 40 ft., as had been indicated by previous soundings.

It was evident, therefore, in order to have a uniform foundation over the entire area of the caisson, it would be necessary to go down fully 40 ft., and this depth was extended to 45 ft., so as to have the timber entirely below the iron bed.

The area of the caisson, 17,000 sq. ft., is so large that no uniform stratum over the whole surface would be likely to be found anywhere within this drift formation at any moderate depth below the water level. No better foundation could have been wished for than that found in chambers Nos. 3 and 4, provided it had extended all over.

Nine-tenths of the boulders were trap, transported hither during the drift period from the palisades of the Hudson. Owing to their hardness, they had resisted the wear of time the longest. They occurred of all sizes, from 1 cubic foot up to 250. Boulders of quartz and gneiss rock occurred more rarely. Two large boulders of red sandstone were also found. The softer varieties of rocks had all been worn down to pebbles. A collection made of the various specimens encountered during the descent of the caisson presents a complete series of the rocks found for a hundred miles to the north and north-east of Brooklyn.

LOWERING THE CAISSON.

The adoption of a regular system for lowering the caisson uniformly was a matter of much experiment at the beginning. No amount of pressure could force the bearing surfaces of it through the ground without crushing the cast-iron shoe at the cutting edge, or smashing the bearing frames. A few days' experience demonstrated that fact. On the contrary, it became a matter of primary importance to dislodge all boulders in advance before the shoe or the frames came to a bearing upon them.

All this work had to be done under water, because there was usually along the shoe a trench filled with water communicating with the water outside, and this trench was connected with cross trenches under the frames, which in time supplied the large pools around the water shafts.

The finding of these boulders in advance was a laborious, disagreeable, never ending task. Its performance fell entirely upon the engineering staff in the caisson, Col. Paine and Mr. Collingwood, and the principal foremen, Messrs. Young and Clark. The perimeter of the shoe or cutting edge measures about 540 ft.; adding to this the five frames of 102 ft. each gives a total length of 1,050 lineal feet of bearing surface, every inch of which had to be carefully probed under water twice a day with a steel sounding bar, and the proper conclusions drawn as to the best means of moving the rocks, hard pan, and other material found. Each shifting gang of laborers had to be informed anew whenever their turn of work came on. Being under water, this, besides, became a matter of memory and not of mere eyesight. Moreover, a settling of the caisson of 6 in. or a foot would bring to light an entirely fresh crop of boulders in new positions, and very often half without and half within the caisson.

The shoe being of necessity unsupported, it was left for the frames to support so much of the weight of the caisson as was not balanced by the air pressure.

The first attempt in the operation of lowering was to leave small pillars of earth under the frames, about 3 ft. square, and from 6 to 8 ft. apart, the intervening earth being taken away, and forming part of the trench. These pillars were to be then uniformly undermined, and the caisson lowered in that manner. It was soon found that the pillars usually concealed the head of a large boulder, which required their premature removal. Again, the water would wash them down, and still oftener the laborers in adjacent chambers not working in unison, would undermine them and destroy their effect.

The plan next adopted worked very well, and was pursued to the end. It consisted in supporting the frames every 8 ft. on two wooden blocks, 12 in. square and 2 ft. long, one above the other, with four stout oak wedges interposed between the blocks and bottom of the frame. A continuous trench, 2 ft. deep and 4 ft. wide, was thus maintained under the frames, giving ample working room for the removal of boulders. Whenever the shoe had been cleared out for 6 in. in advance, these wedges were then loosened with sledge hammers, one by one, and

frame by frame, until the caisson slowly settled. Then either new blocks were put in of a smaller size alongside, or, as was usually the case, they were allowed to crush. Very often a sudden descent of the caisson would crush half the bearing blocks, until brought up by the shoe. The operation was analogous to the splitting out of blocks and wedges during the launch of a ship.

The bottoms of the frames were originally 2 ft. wide. This width was found too great to allow of the easy removal of rocks from underneath. They were, therefore, cut down to a width of 1 ft. The lower ends of the frames were likewise cut loose from the side of the caisson, to allow more easy access to the point of the junction. This reduction of bearing surface added materially to the risk in case of accident.

REMOVAL OF BOULDERS AND EARTH.

Boulders occurring inside of a chamber were usually left undisturbed until the caisson had sunk sufficiently to enable us to attack them above the water level. They were then split into manageable blocks by plug and feather.

Boulders under the frames presented more difficulty. The ground in which they were embedded was cut away with steel bars as much as possible; they were then drilled under water and a lewis inserted. The appliances for pulling them out of their beds were various. Those first in use consisted of double sets of block and tackle, aided by winches and crowbars, with a gang of 30 or 40 men hauling at the ropes. All this force was frequently found ineffective; the strain required being usually from two to three times the weight of the stone. The cause of this lay in the air pressure, which amounted not only to the 15 lbs. of atmospheric pressure, but the caisson pressure in addition, the whole being effective by reason of the water-tight clay in which the stone was imbedded. As soon as the boulder was loosened in its bed to a slight extent, it soon followed. These hauling arrangements were replaced after a time by three of Dudgeon's hydraulic pulling jacks, two of 10 tons and one of 15 tons capacity. This proved to be a very effective instrument. They were usually attached to heavy screw bolts let into the roof of the caisson, and formed part of a chain leading to the stone. Many boulders, however, resisted the united efforts of all three jacks.

The removal of the hard earth could be effected at the beginning only by the use of steel-pointed crowbars driven in with sledge hammers. Under water the blow of a pick has but little effect. The long-handled, round-pointed shovel answered best for lifting the material out of the water into wheelbarrows.

After the caisson had been lowered about 2 ft. it became possible to build dams around the trenches under the frames and bail out the water. This enabled us to see the work at hand, and materially lightened the labor attending it. These dams were shifted from trench to trench, care being taken always to leave an open trench leading to the water shaft.

The removal of the water from the trenches was accomplished partly by hand bailing, then by air siphon pumps and steam siphon pumps, and finally by compressed air itself, throwing it entirely outside of the caisson through pipes introduced through the timber and masonry.

To work the air siphon a complete system of $1\frac{1}{2}$ in. pipes was placed in the caisson with suitable connections. Through these pipes air was introduced under a pressure of 60 lbs., one of the main air pumps being set apart for that purpose. The pump was constructed on the principle of a Giffard injector, and as the duty required was simply to lift the water from 3 ft. to 4 ft., it was expected to work well, but it never did. Steam was then introduced in place of extra compressed air through the same pipes. This answered the purpose admirably, draining the trenches in a short time. It afforded an ocular demonstration of the operation of a Giffard injector, since the caisson simply corresponds to the interior of a huge boiler, and steam, under the same tension as the caisson pressure, produced the desired result. One circumstance, however, led to its early abandonment. When the pump had worked a few minutes, the temperature would rise to 100 deg., driving the men from that particular chamber. Recourse was then had to a simple flexible suction hose, communicating with a pipe leading out of the caisson. The end of this hose was held in the water, so that about $\frac{3}{4}$ of it was sub-

merged. The compressed air rushing through the remainder of the opening kept the whole column of water in motion at a rapid rate. This mode is, of course, attended with a slight loss of compressed air, but it proved far simpler to raise the water 40 ft. out of the caisson than 4 ft. inside of the caisson. Soft mud and fine sand passed out readily with the water.

BOULDERS UNDER THE EDGE.

The occurrence of large boulders under the shoe proved to be the most serious obstacle to a rapid sinking of the caisson. As long as the water from without still had free communication with the air chamber, they had to be attacked under water, the most tedious part of the operation being the removal of the earth in which they were imbedded. When the stones extended more than 2 ft. or 3 ft. outside of the caisson no attempt was made to haul them in, but they were slowly chipped to pieces, until enough had been removed to enable the edge of the caisson to clear them.

As soon as the dredgers were at work, the excavated material was dumped around the outside of the caisson, with a view of stopping the ready passage of water under the shoe. This was effected after a time. Then, by building a clay dam around the boulder on the inside, and filling up the adjoining space with bags, it became possible to dig a comparatively dry pit underneath, into which it was tumbled, provided it was not too large.

Several boulders occurred which delayed all settling for 3 or 4 days at a time. In order to gain time, a special force of some 30 men was then organized, who worked only at boulders from 11 o'clock at night until 6 A. M., when the regular gangs came to work.

It may truly be said that the result of the first month's work was not very encouraging. We had a material to deal with which is difficult to remove, even under favorable circumstances, on top of the ground. The rate of descent had not averaged 6 in. a week, and the boulders were increasing instead of diminishing in numbers. To look forward to a rate of lowering of even 1 ft. per week seemed hopeless.

The work inside was rendered still more disagreeable by the frequent "blows," caused by the rushing out of the compressed air under the shoe. This would continue for several minutes, until a returning wave of inflowing water from some other part of the caisson would check it, leaving, however, a foot of water all over the ground for some time, until the air pressure drove it out, and the occurrence repeated itself. The trenches were usually flooded thereby and had to be pumped or bailed out incessantly. These flows were caused by change of the water level outside, due partly to passing steamboats, but principally to constant changes in the tide; the thick fog which accompanied them was always an indication that they were transpiring in some part of the caisson.

On the other hand we were daily gaining in experience. The workmen became more accustomed to the novel situation and more practised in the particular kind of work to be done, and the heaping up of a bank of earth around the outside led us to hope that when the caisson had sunk a few feet lower the conditions of air pressure and the general regimen of the caisson would become more equable, and, what was of more importance, the free access of water from without would probably be materially curtailed. These expectations were more than realized. In a short time water became as scarce as it had been plentiful before.

BLASTING.

When the caisson had arrived at a depth of 25 ft. below the water level, the boulders became so large and numerous as to compel us at last to resort to blasting. The idea of using powder had been entertained all along, yet our imaginary fears, supported by plausible reasoning, had prevented the attempt thus far. It was supposed that the effect of the explosion would produce a violent concussion in that dense atmosphere, rupturing the ear-drums of the men. Again, the effect upon the doors and valves of the air locks might be such as to endanger their safety.

The principal apprehensions were, however, in the direction of the water shafts. Here were 2 columns of water 7 ft. sq., and ultimately 45 ft high, held in a critical balance by the pressure inside, the margin of safety being an immersion

of less than 2 ft. on part of the lower edge of the shaft in the pool surrounding it. The sudden explosion might rapidly depress the level of the pool and allow the air to escape underneath, which would be fatal both to the caisson as well as the men inside. Again, as regards blasting under the shoe and partly outside of it, it was feared that the explosion migh cause a vent outward, followed by a rush of air.

The result, however, justified none of these apprehensions.

First, a trial was made by firing a pistol with successively heavier charges, then small charges were fired off by a fuse, and soon blasting became an established system. The good effects were at once apparent in the lowering of the caisson from 12 in. to 18 in. per week in place of 6 in.

The first entry into the caisson was made with considerable misgivings, but none of our fears were realized.

The total settling that took place amounted to 2 in. in all. Every block under the frames and posts was absolutely crushed, the ground being too compact to yield ; none of the frames, however, were injured or out of line. The brunt of the blow was, of course, taken by the shoe and sides of the caisson. One sharp boulder in No. 2 chamber had cut the armor-plate, crushed through the shoe casting, and buried itself a foot deep into the heavy oak sill, at the same time forcing in the sides some 6 in. In a number of places the sides were forced in to that amount, but in no instance were they forced outward. The marvel is that the air tightness was not impaired in the least.

The 9 courses of timber forming the sides of the air chamber were permanently compressed to the extent of 2 in., as was shown by protruding bolt heads and the shearing off of a number of diagonal bolts. The lower sills of the frames were also torn where they came upon boulders.

The weight of the caisson at the time was 17,675 tons. The air blew out so suddenly that this weight must have acted with considerable impact in falling through the space of 10 in. The bearing surface at the time was as follows : The 4 edges of the caisson, 550 ft. long and 7 in. wide, amounting to 322 sq. ft.; the 5 frames, each 100 ft. long and 1 ft. wide, resting on 12 blocks 1 ft. wide, amounting to 60 sq. ft., and giving a total of 382 sq. ft. to meet the above pressure. This at the rate of 46 tons per sq. ft.

But more than one-half of the shoe was undermined to a depth of 1 ft. or more, which reduced the practical bearing surface by nearly one half. At the commencement of the shock there was, therefore, a pressure of 80 tons per sq. ft., no allowance being made for impact, which may have doubled this rate. The caisson had settled 10 in. The shoe had buried itself so as to present a width of 12 in., and through the crushing of the blocks the frames were in many places resting bodily on the ground. The settling had, therefore, stopped when a bearing surface of 775 sq. ft. had been reached, giving a pressure of 23 tons per sq. ft.

As the caisson proceeded in its downward course, the disproportion between the dead weight above and the air pressure from below became greater and greater. For instance, on the 15th of November, the escape of air under the shoe was so strong that no more than 10 lbs. of air pressure could be maintained. The over-pressure entailed thereby was 12,240 tons. This was received by a bearing surface of 280 sq. ft., causing a pressure of 44 tons per sq. ft.

In order to meet this constantly increasing overweight, a large number of additional shores were introduced into the caisson. They rested upon a block and wedges, and supported a cap spiked against the roof. The presence of these shores added considerably to the labor of lowering the caisson, and diminished the available working space otherwise. They gave, however, a positive assurance against any possible crushing weight from above, and could, moreover, be easily removed when a boulder was taken out, which could not be done with the permanent frames.

The downward movement of the caisson was usually so impulsive that the blocks under the posts were allowed to crush and were subsequently dug out. In fact, their crushing was the only indication we had that any portion of the caisson was bearing particulary hard. The noise made by splitting of blocks and posts was rather ominous, and inclined to make the reflecting mind nervous in view of the impending mass of 30,000

tons overhead. No satisfactory estimate could be made of side friction. There must have been some, but of a very irregular character. At times an outside boulder would apparently hold one end of the caisson until a bolt-head or part of the timber gave way. The batter on the outside being 1 ft. in 10 ft., was calculated to relieve the caisson from side friction. The workmen, however, never dug out far enough behind the shoe, thus causing great friction for several feet up the sides, and pressing in the sides to as much as 9 in. in some places. The side friction probably never exceeded 3,000 tons. The larger the base of a caisson the smaller is the percentage of side friction available to counteract downward pressure, whereas, in a narrow caisson penetrating an uniform sand, it is often sufficient to counterbalance the whole weight.

A CURIOUS INCIDENT.

A few words will suffice to explain the mode of operating the supply shaft. It consists of a tube 45 ft. long and 21 in. diameter inside, with a door at the bottom opening into the air chamber, and a long door on the top, through which the material is thrown in. When the upper door is open, the lower one is held shut by the air pressure, assisted by 2 iron clamps worked by levers. As soon as a certain quantity of material has been thrown in, the upper door is pulled up, and the compressed air being thus allowed to enter, firmly closes it. When the shaft is filled with compressed air, a signal is given to the attendant below, who removes the lugs, the door falls, and the contents of the shaft drop into the air chamber. The operation is very simple and rapid, and perfectly safe with the most ordinary precaution. Two of these shafts were found ample to furnish all the material required for filling up the caisson. They had worked well for 5 weeks, but danger always steps in when, through use and familiarity, the attendants become careless and reckless. It had occurred at times that a charge of building stones or brick would become jammed, and only part of a load would drop out. To ascertain this fact a string with a weight was let down from above each time, so as to avoid putting in a double charge. Upon this occasion a charge had jammed, the men dumped in another, without measuring the depth either before or after, and then gave the signal to the man below, without shutting the upper door, or letting in the compressed air. The second charge happened to loosen the first, and the two together overcame the pressure against the lower door, when the lugs were turned. As soon as this happened, the air commenced to rush out of the caisson with a great noise, carrying up stone and gravel with it. The men above ran away, leaving those below to their fate. Any one with the least presence of mind could have closed the upper door by simply pulling at the rope.

I happened to be in the caisson at the time. The noise was so deafening that no other noise could be heard. The setting free of watery vapor from the rarefying air produced a dark, impenetrable cloud of mist, and extinguished the lights. No man knew where he was going, all ran against pillars or posts, or fell over each other in the darkness. The water rose to our knees, and we supposed, of course, that the river had broken in. It was afterwards ascertained that this was due to the sudden discharge of the columns of water contained in the water shafts. I was in a remote part of the caisson at the time; half a minute elapsed before I realized what was occurring, and had groped my way to the supply shaft, where the air was blowing out. Here I joined several firemen in scraping away the heaps of gravel and large stones lying under the shaft, which prevented the lower door from being closed. The size of this heap proved the fact of the double charge. From two to three minutes elapsed before we succeeded in closing the lower doors. Of course, everything was all over then, and the pressure, which had run down from 17 to 4 lbs., was fully restored in the course of 15 min. A clear and pure atmosphere accompanied it. The effect upon the human system and the ears was slight, no more than is experienced in passing out of the airlock.

Under the head of "Fires," Mr. Roebling details the history of the fire of December 2.

LIGHTING OF CAISSON.

The subject of illuminating a caisson in a satisfactory manner, is rather a difficult

problem to solve. A powerful light is of prime necessity, to overcome the want of all reflecting surfaces, to penetrate the thick mists usually occupying such places, and to illuminate every foot of a soil which was anything but uniform in character. The burning of candles is attended with an intolerable amount of smoke, resulting from a rapid but incomplete combustion. This nuisance was overcome somewhat by reducing the size of the wick and of the candle, and by mixing alum with the tallow, and also steeping the wick in vinegar. The inhaling of so much floating carbon is very injurious to the lungs, as the lampblack remains in there for weeks and months. Nevertheless candles have to be used more or less for all special work requiring illumination close by. Lamps are of little account, since they smoke more than candles, and the oil is dangerous in case of fire.

Fortunately, the existence of an establishment in New York for the production of oxygen gas in large quantities and at moderate prices, made the introduction of calcium lights quite feasible.

ORGANIZATION OF WORKING FORCE.

Each shift of men worked in the caisson 8 hours at a time, the first watch from 6 A. M. to 3 P. M., including one hour for breakfast; the next watch from 3 P. M. to 11 P. M., including one hour for supper; then a special night gang from 11 P. M. to 6 A. M.

The majority of the men took their meals along and remained down the full 8 hours without any injury.

The 2 day shifts alternated from week to week. They consisted of 1 general foreman, 6 assistant foremen (1 for each chamber), and 112 laborers. The special night gang was composed of 1 general foreman, with 2 assistants and 40 laborers, making a total force below of 3 general foremen, 14 assistants, and 264 laborers. This force was constantly recruited from time to time, and an inspection of the time-books shows that 2,500 different men have worked in the caisson.

On deck there were double shifts of engineers and firemen to run the excavating engines, and engines for running the dirt cars, also 2 gangs for attending to the dumping of the latter. In addition there were the engineers for the air compressors, and stone hoist engine, blacksmiths, machinists, and gas men, one gang to remove the boulders brought up by the buckets, a carpenter's force of 25 men, and 30 men for setting masonry. The total daily force amounted in all to 360 men.

DOCK.

During the winter months the substantial dock resting on top of the caisson, on the river side, was completed, filled in, and provided with a track, turn-tables, and unloading derrick.

NEW YORK CAISSON.

The plans for this caisson were perfected in the summer of 1870. A contract for its construction was made in October, with Messrs. Webb and Bell, the builders of the first caisson, the iron work being done by John Roach & Sons, of the Morgan Iron Works. It was built at the foot of Sixth street, New York, the old yard in Greenpoint having been abandoned for shipbuilding purposes.

A rather severe winter, with delays on part of the iron work, prolonged the completion of it to the 8th of May, on which day it was launched with the same success attending the first launch. It is now lying in the Atlantic Basin, where 7 additional courses of timber and concrete are being put on preparatory to its removal to its permanent site. In its construction this caisson is in its general features a duplicate of the Brooklyn caisson. It is built of yellow pine timber, the air chamber being lined with a thin skin of boiler plate on the inside. The roof consists of 5 courses of yellow pine sticks, 12 in. square; the inclined sides surrounding the air chamber are also of yellow pine, and are 9½ ft. high on top, and taper to a rounded cutting edge of cast-iron, 8 in. wide, and enveloped by an armor of boiler plate.

The timbers in all the courses are scarfed and bolted together with screw bolts and drift bolts. About 180 tons of bolts were used in the fastenings. The dimensions of the base are 172 by 162 ft., covering an area of 17,544 sq. ft. Its length is 4 ft. greater than the Brooklyn caisson.

The air chamber has a height of 9 ft. 6 in., and is divided into 6 rooms by 5 main frames. The rooms vary from 25 to 30 ft. in width, by 102 ft. long, and are

subdivided by lighter secondary frames running through the middle. In addition there are two heavy cross frames extending through the whole length of the caisson. The amount of bearing surface is 18 per cent. of the whole base, and will be increased to 25 per cent. of the whole base by reason of the sloping sides, in case the caisson should sink into the soil 2 ft.

The main frames are of solid timber, and 4 ft. wide, composed of two central ties of horizontal timber and two outer rows of posts. They are secured to the roof by long through bolts, extending through the lower three courses of the roof and are heavily braced sideways. The ends of the frames are secured to the sides of the air chamber by knees and iron straps. Each frame is pierced by doorways of ample size to afford communication between the adjoining chambers.

The secondary frames are open work, composed of posts and sills, and can be strengthened if the necessity should arise. An iron skin lines the inside of the air chamber. The iron is light boiler plate, of No. 6 gauge. A light iron was purposely selected in order to overcome to some extent by its buckling, the difficulty arising from the expansion and contraction of so large a surface rigidly bolted to an unyielded mass of timber. In addition, a series of expansion joints of angle iron were put in transversely to aid in taking up the contraction. No trouble has been experienced from this source since the launch. All spaces between the skin and the timber have been filled with cement.

FLOOR.

The New York caisson was launched with a temporary floor extending over the whole base. This was made necessary by reason of the shallow water in front of the launching ways. The floor will remain until the caisson is permanently grounded on the river bed, and will help materially in maintaining a level position of the same.

The air chamber will not be inflated until the caisson has touched bottom, and enough masonry has been laid to prevent its rising at high tide and from the pressure of the compressed air. This floor then comes into play to distribute uneven pressures until access is had to the air chamber and the work of excavating has commenced.

TABLE OF QUANTITIES.	NEW YORK CAISSON.
Length over all..............	102 ft.
Breadth....................	102 ft.
Height.....................	14 ft. 6 in.
Area of base.................	17,554 sq. ft.
Quantity of timber...........	118,00 cub. ft.
Weight of bolts..............	180 tons
Weight of ironwork..........	200 tons
Launching weight of caisson..	3,250 tons

SHIFTING STUFF.

From "The Building News."

In all contracts, whether they relate to the erection of a Crystal Palace, the construction of a railway, or the cutting of a Suez Canal, there is invariably a particular kind of work, a certain portion of the estimate, that pays better than any other. This is by no means in proportion to the quality of the work, or its price, although it unquestionably depends, generally speaking, upon the quantity. Occasionally, items of small amount, for which a large price is allowed, are a good thing for the contractor ; but, as a rule, the items heavy in quantity and small in price per unit of measurement, pay the best. A genuine contractor likes a "big job." He likes to deal in generalities. Petty, insignificant contracts allow no scope for the exercise of those peculiar talents which have always distinguished the English contractor. On the other hand, a large contract affords facilities for, and in fact demands, all the energy that he possesses; the readiness, aptitude for contrivances and make-shifts, promptitude in seizing every occasion that presents itself and turning it to account, indefatigable attention and untiring perseverance that all our great contractors are endowed with, are then capable of being displayed to the best advantage. It must not be supposed that those gentlemen pay no attention to, or have no knowledge of, details of works. The truth is that the reverse is the case. The most intimate knowledge of the

value of details, and a close study of their immense importance and bearing upon work, is indispensable to every one who intends to make money by contracting. But this acquaintance with the minutiæ of work does not prevent the contractor preferring to deal with them *en masse.* In order to traffic in tons and parts of tons, one ought to be acquainted with the price of the article per cwt. or per lb., as the case may be; but one is not in consequence limited to trading in the smaller amounts. There is just the same difference between one of our merchant princes and a small retail tradesman, as there is between a Brassey and a local builder and contractor. So well is this difference recognized and established among the parties themselves, that a contractor of the former calibre would no more think of tendering for certain descriptions of contracts than a wholesale city merchant would consent to supply private families with goods.

The days most fortunate for contractors were those which witnessed the infancy of railways, and it is incontestable that the most paying parts of the contracts was the earthwork. In other words, the amount of stuff to be shifted was the pith and marrow of the contract. This was always the heaviest item in the construction of the early lines of steam communication. Attempts were then made by engineers to approximate to the *beau ideal* of a railroad—namely, that which should have no curves and no gradients. No wonder there was an immense quantity of stuff to be shifted ; no wonder that the earthworks were heavy when a curve having a radius of 1 mile was considered sharp, and a gradient of 1 in 100 was regarded as almost too steep for the powers of a locomotive. If we draw the proper distinction between rural and urban railways, it will be admitted that in the construction of the former, especially of the earlier examples, heavy cuttings necessitated correspondingly heavy embankments. The engineer, in order to avoid the "running to spoil" of any of the earthwork, endeavored to adhere to the golden rule so familiar at that time to young members of the profession : "Always make your cuttings equalize your embankments." At the present time this rule, though correct in the main, is not so strictly adhered to as formerly, nor could it be, bearing in mind that our system of railway construction has undergone great modification since the days of the fathers of steam locomotion. Embankments are easy enough to construct when there is plenty of stuff to be got for the purpose from the nearest cuttings, or even when, at the worst, they can be made up from side cuttings. But the case becomes very much altered when an embankment is necessary and no stuff can be got in the neighborhood to make it with. Abundance of examples of this are to be seen in the vicinity of London, where earthworks are replaced by viaducts of brickwork. Instances have occurred in the construction of railways in which a viaduct has been built in the place of an embankment, not because stuff could not be obtained along the line for a solid bank, but because the cutting from which the supply would have to be drawn was at too great a distance, that is, the "lead" was too long. It was cheaper to use a more expensive material than to run the other so far. It is in balancing up these several discrepancies, and forming a correct judgment of the method to employ, that the genius of the contractor is displayed. It must be borne in mind that "shifting stuff" in the open country, and in a city similar to London, are totally different matters, and that our remarks apply, to their full extent, only to the former description of work.

Assuming that our statement respecting the comparative advantage and pecuniary benefit to the contractor of a large amount of earthwork in a contract is accurate, the question will naturally be asked—why ? A little consideration will demonstrate the reason, and in order to render the subject clearer, let us compare earthwork with brickwork. In the first place it is a great deal more difficult, particularly for an engineer, to estimate what the cost of shifting so much stuff in certain situations will come to, than it is for him to arrive at the cost of so much brickwork. The price of bricks per thousand can be ascertained to the fraction of a shilling ; the cost of the labor to build a rod of ordinary brickwork can also be known to the same degree of accuracy ; and, moreover, there is only one way of going to work about it, in whatever locality the operations may be car-

ried on. But it is far otherwise with earthwork. Independently of the fact that the price varies very widely with the nature and situation of the material, there are numerous ways in which the shifting may be accomplished. It may be run in barrows, carted away, removed in barges, as occurred during the construction of the Thames Embankment and the Metropolitan District Railway, or conveyed away upon a tramway, either by horse or steam power. The difficulty of arriving at a correct estimate of the cost of shifting stuff was well exemplified in the early days of railways on the Continent. The French engineers made their usual mathematical and elaborate calculations respecting the effect that the different "leads" would have upon the price, and their own native contractors followed suit. As may be imagined, the French tenders were enormously high. Without in the least troubling themselves about calculations of any but a very simple arithmetical character, the English contractors made their estimates, which were much lower than those of their foreign *confrères*, and obtained the contracts. It is not too much to assert that to this circumstance of readily and correctly estimating what the cost of shifting stuff would be is due the great amount of foreign work executed by English contractors. It enabled them to get a footing in foreign countries which they have never lost. Another reason why earthwork is usually so paying a job for the contractor is, that he is at liberty to use any method he pleases of executing it, which is not the case with other descriptions of work. He is not hampered by a variety of conditions which are attached to other items. After some practice and experience, it is not surprising that the contractor becomes endowed with a special faculty of devising means to execute earthwork cheaply and effectually. That this is the case is amply manifested by the circumstance that some contractors tender for earthwork, if not altogether, at least in preference to other descriptions of work. Again, on a large job, it is a common occurrence to let out the shifting of stuff to sub-contractors, who not only make a profit out of it themselves, but leave a balance also to their employers. There is, perhaps, one exception to the opinions we have expressed—that is, where the shifting of stuff takes the shape of water work. But, at the same time, a high price is always allowed for such work, as there are so many contingencies to be provided for. It must, however, be confessed that there is always some risk incurred in all works in which water is present; and here, as in many similar instances, the contractor must put a little faith in his good luck.

BOILER EXPLOSIONS.

From "Engineering."

The labors of the second Committee upon Boiler Explosions have come to an end, and its report has been submitted. It will be remembered that a select committee was appointed last year, and that in June and July it held many sittings, received much evidence, and finally recommended that another committee should be appointed at the ensuing session to conclude the work of investigating the subject. On the 25th of April last, this second body finished its work, and on the 20th of June sent in the report. One of the conclusions arrived at is, that a general system of boiler inspection cannot be insured without making that inspection compulsory, and the committee is not prepared to recommend for adoption any system of this nature.

This conclusion is arrived at partly because it is believed a large number of explosions occur annually from causes that are and would continue to be independent of anything that could be prevented by periodical inspection, and partly because it is considered doubtful whether compulsory inspection would not lessen the responsibilities of owners, and tend to make them careless as to the class of men they employ.

The most important recommendation contained in the report is, "that it be distinctly laid down by statute, that the steam user is responsible for the efficiency

of his boilers and machinery, and for employing competent men to work them, and that in the event of an explosion, the onus of proof of efficiency should rest on the steam user." It is also recommended that, as an average coroner's jury cannot satisfactorily investigate the causes of an explosion without the aid of competent professional advice, that whenever an explosion occurs, the user shall report the same to the district coroner, who shall communicate with the Board of Trade, which shall instruct one of their competent surveyors to attend the coroner and assist him in his investigation.

Among the resolutions proposed were those having reference to the inspection of new boilers, as follows:

"That it is desirable that a preliminary inspection of boilers should take place, so as to secure :

"(*a*) That the boiler is capable of bearing a working pressure equal to that at which it is intended to be worked.

"(*b*) That it has all necessary fittings to prevent the steam ever attaining a greater pressure than that prescribed, and to secure a proper supply of water to the boiler.

"(*c*) That the boiler is so fixed as to afford ready means for external examination.

"That an inscription should be put up on a conspicuous part of every boiler to the effect that, when new or last examined, it was testified to be fit to work up to a certain pressure, to be therein stated."

Besides this the resolution refers to the provision of sufficient penalties for those owners who are guilty of negligence, or for those who work a boiler without a certificate.

In declining to recommend to the Government any scheme for the compulsory inspection of boilers, the committee has doubtless been influenced by the evidence and opinions of the large number of witnesses examined, and the majority of whom, whilst advocating strongly general inspection, deprecated Government interference, and proposed plans, most of them more or less practical, but none of which would meet all the requirements of the case.

The experience of the leading Boiler Inspection Associations militates against the conclusion of the committee, that a large number of explosions occur from causes unpreventable by inspection. The statistics of boiler explosions show that those users who encourage periodical inspection, rarely, very rarely suffer, whilst the bulk of accidents happen to uninspected boilers. It is true that this almost total immunity from accident, on the part of the former class, cannot be ascribed entirely to inspection, for those users who adopt this precaution naturally observe all the other conditions of safety, and are, in fact, the careful class of steam users, as opposed to the other and larger class of careless owners.

The committee, however, endeavors to get over this difficulty of compulsory inspection by throwing the entire responsibility upon the steam user, and recommending that he should be made responsible not only for himself, but for his servants, the onus of proof of efficiency both of boiler and workman resting upon him. This we consider in itself a wise conclusion ; we have repeatedly in these pages called attention to the gross carelessness and the astounding ignorance that conduce so often to boiler explosions, and we have always advocated that steam users should be made responsible for any possible damage they may cause. At present it is too often the case that the unfortunate servant in charge of the boiler which explodes is saddled with all the responsibility, and takes the punishment. In some cases this is just, but in how many cases is it unjust? If the man is ignorant of his business, it is the fault of the master that he employs him. If the boiler is unreliable and unsafe, it is not the crime of the workman, who has to gain his livelihood by attending it, but that of the employer who allows it to be worked. How many men there are in the position of Lambert, who gave evidence before the committee, and who said with reference to the boiler he looked after, "I can tell you that when the engine is working at 20 lbs. I am much more happy than when she is working at 40 lbs.," and who works under the settled conviction that "he should be up in the air where the boiler is, if the boiler should burst!" These opinions may, of course, be prejudiced, and his boiler may be perfectly safe, but they are the exact opinions of a large body of working men, who are compelled to undertake risks

every hour of the day, and who have no means of helping themselves.

Doubtless a rigid observance of the committee's resolution, that responsibility should be placed upon the users, would do a great deal to ameliorate the present state of affairs; for, having the fear of consequences before them, masters would naturally practise caution, and take such steps as they deemed best suited for their protection. But in doing this they would be likely to run into other dangers. We are not speaking now of the large users of steam power—the boiler aristocracy, so to speak—but of the crowd of small owners, amongst whom the greatest danger of explosion occurs. Such a legislation as that proposed would be the signal for a large number of inspecting and insuring associations to come into existence, many of which would probably be of a class totally different to the excellent ones now at work.

These might find lucrative business, but they would prove of little service to the steam user, who, lacking either judgment or prudence, places his reliance in inspectors whose ability and probity are not proved. So, then, he would continue in false security, until an explosion, and its consequent penalties, might end in ruin.

The committee are of opinion that general inspection would be impossible without compulsion, but they appear to overlook the fact that unreliable inspectors will conduct many into the paths of penalty prepared by legislation, whilst those who take no precaution will, it is true, be punished, but not till after the mischief that ought to have been avoided, has occurred. Prevention is in all cases better than cure. Prevention can practically be achieved by proper inspection, but proper inspection cannot be universally secured unless under compulsion; therefore, compulsory inspection ought to precede the penalties which should be inflicted under all circumstances where carelessness can be traced to the user.

With regard to the efficiency of boiler tenters, employers would, if a vigorous and just legislation existed, use every precaution to obtain good men, who might be compelled to show certificates of capacity before obtaining employment. In fact, Lambert, the engine driver, in his own way, summed up the requirements very justly in our opinion: "That inspection should be compulsory, and done by the Government, and that inspectors should be appointed who should see that there were competent men employed to take charge of engines and boilers, and the same to receive a certificate that he is a competent man."

That Government inspection would be considered as oppressive by the majority of boiler users we can readily believe, but as we have before expressed our opinion, we consider that it would be the only really efficient form of inspection, if carried on under sufficiently elastic conditions. With the assistance and experience of the several able men now conducting the leading associations for the same purpose in this country, the work could be systematized and so arranged as to interfere but little with the convenience and prejudices of steam users, in fact, to a less actual degree than would the operation of a number of independent bodies; of course the sentimental grievance against Government interference would probably be of long duration.

There can can be no doubt of the value of preliminary examinations of boilers before they are put in use, the extended business of manufacturing boilers, the keen competition that exists in the trade, the desire on the part of purchasers to obtain cheap boilers, the willingness on the part of makers to accommodate their customers—all of these causes demand a thorough investigation of boilers before they leave the shop. Whether this will form a part of the new legislation on the subject remains to be seen; if it does not, there will be a serious defect in the Act; if it does, there can be no valid reason why the official inspection should not be extended further, and apply to the 100,000 boilers now under steam in this country, and the explosion of many of which is only a question of time.

The preamble of a bill for the construction of a new line of railway from Preston to Southport has been declared proved. Mr. Brunlees, C. E., the engineer of the proposed line, stated in his evidence that the probable cost of construction would be £144,000; the works were easy, the steepest gradient being 1 in 94.

THE COINING OF GOLD.

The following interesting account of the chlorine process of coining gold, now in use at the Mint, is taken from the "Standard": —

The statements which have been of late made in Parliament and the press, respecting various matters connected with the operations of the Mint have given a public interest to the only notable improvement in the metallurgy of coining which has been made in the present century. Indeed the whole process of coining is so old, and was so far perfected at a very remote age, that after the application of machinery not very much has since remained to be done. There was, however, one trouble, causing great annoyance, which had existed from time immemorial, and which was the more vexatious that no inspection of the metal when received could effectually guard against it—brittleness. The ingot might be, to all appearance and test, as tough as it should be for the coinage, and yet when the processes of minting were far advanced, a portion of the mass might turn out of such brittleness as to necessitate its return to the importer—of late years almost solely the Bank of England—and thence again to the refinery. This difficulty has been entirely overcome, and by a process so inexpensive as to be practically costless; and now, instead of returning the gold as heretofore, it is treated at once in the Mint itself, and the full coinage of the quantity brought in is completed, without even the importers being made aware at all of any imperfection in the condition of any of the ingots. The chlorine process by which this admirable result is effected is equally simple as inexpensive. The intractable gold is merely put into a crucible and remelted, having, while in that state, a jet of chlorine gas passed through it by the insertion of a clay pipe into the mass of liquid metal. Thus is effected a combustion of impurities, very much, as one might say for comparison, like the Bessemer steel process, only substituting chlorine gas for common air. In the Mint works a large glass jar about 15 in. or 18 in. high, containing the hydrochloric acid, is placed against the back of the wall of the furnace-house, at about 12 ft. from the ground, and a piece of glass tubing, 8 ft. long, connects it with a chlorine generator below, capable of containing about 8 gallons, and from which a $\frac{1}{4}$ in. pipe is passed through the wall, the clay nozzle of which is inserted into the crucible for about 5 min. at each operation.

In thus treating brittle gold, two grave points of consideration had to be met boldly at the outset. The brittleness in the standard gold arises from the presence, in very minute quantity, of lead, antimony, arsenic, or bismuth. This minute quantity—as little as 1.1900th part—sufficing to render the gold too brittle for coining—made it necessary, on the one hand, not to employ any process which should volatilize and waste the gold. On the other hand, the chlorides are either volatile, as in the case of those metals which occasion brittleness, and in such combinations are driven off by the heat; or, as in the case of silver, melt into a fluid mass which floats on the surface of the gold. If, however, we compare the loss of the valuable metal in the chlorine process, as conducted at the Mint, with the loss regularly experienced in the ordinary process of gold-melting, which is 1 gr. per troy lb. of gold, we shall find that the results are highly satisfactory; in fact, the initial loss by the chlorine process may be briefly stated as 19 parts in 100,000, whilst the experience of the melters of the Mint is, that the ordinary loss by ordinary melting amounts to 17 parts in the 100,000, of which in both cases the greater portion is recoverable. The bearing of this success in manipulation goes to show that at the extremely high temperature at which the operation is conducted, chloride of gold does not exist, being in fact decomposed, whilst the chlorine combines rapidly with the baser metals. Any very light loss of gold, therefore, that may take place, must arise either from its being mechanically carried away, or from the production of a volatile compound of gold and the volatile metal with the chlorine introduced. Of the inexpensive nature of the apparatus, and the materials employed in the chlorine toughening process—for the gold so treated comes out of the crucible perfectly workable—we

may say that the amount of chlorine required for £10,000 worth of gold would not cost 2s., and that the whole apparatus for generating it could be put up for a couple of sovereigns.

Another topic deserves public notice, namely, the perfectly innocuous character of the process. The Mint operations are at all times, on account of the rarity and value of the materials dealt with, very small in scale compared with the metallurgical processes of the great manufactories of the ordinary metal industries; and even of these, the toughening process is only applied to the smallest quantity of the most valuable metal. There is, and has been, no need for its employment for more than a total of 3 days a-year, taking in the most active seasons, and then only for a few hours at a time. Between the generator and the furnace every joint of the apparatus is made tight, and there is no escape for any of the gas, excepting up the flue—and what, indeed, if the whole went up, would that quantity, ejected from the top of a lofty stack, during 3 or four hours' work, into the full current of the winds, effect in the way of nuisance to any neighborhood? Even in a perfectly calm day, the amount of chlorine so disseminated in the atmosphere would not be enough to be smelt; and, if it were, it is by no means unwholesome, but, on the contrary, a very effectual destroyer of disease-malaria. It is a pity, therefore, that critics who are not chemists enough to understand the point in question should attempt to prejudice the Government and the public against, not only this useful operation, but also against the removal of the Mint to Whitefriars, where it would have a frontage towards the Thames Embankment, by raising phantoms of nuisances and annoyances which never did, and never can, have any reality. To discuss the question of a transference of the Mint from Tower-hill to the vicinity of the Strand is not part of our present purpose; but we may add, in passing, that a small manufactory, such as the Mint is, and ever will be, can be much better and more economically managed if compacted in one moderate-sized building than it can be in a multiplicity of buildings, spread over 5 acres, as it is at present.

Returning to our immediate subject, we may note that the gold coins of the country are not fine gold, but an alloy of copper with 916.6 parts of gold in 1,000 of the mixture. This is "standard gold." Brittleness can very seldom be detected in the ingots of pure gold as received, and the friability is often exhibited after the formation of the alloy, the quality of the copper needing careful selection. The alloy, when free from impurities, is tough and malleable, but when, as we have said, there is a small amount of some of the baser metals present, it may be as brittle as loaf sugar. Refining silver and gold, that is, removing either metal from the other, as well as from foreign or impure metals, is ordinarily a long and tedious operation. The process of refining was, however, much simplified by Mr. F. Bowyer Miller, of the Sydney Mint, who found that when chlorine gas is forced through a molten mixture of gold and silver, the latter metal is converted into chloride of silver, which rises through the gold and floats on the surface of the metal, and the separation of the gold and silver is thus easily effected, the quality of the metal proving excellent. This process has been further developed in its direct application to the toughening of standard gold by Mr. W. Chandler Roberts, the present chemist of the Mint, a pupil of the late most eminent Mr. Graham, and associated with that great chemist in his memorable researches on palladium. Mr. Roberts' able report upon this subject combined with the success realized in the practical operations, ought to insure for him a higher recognition than even that of a very useful public servant; and viewing the chlorine system in its other aspect of a refining process, it will be to his pioneering that the credit will be mainly due, should it in this country replace in a few years the existing tedious operation of refinery. Short as is the period since its adoption at the Mint, some 40,000 oz., or nearly $150,000 of brittle gold have been already so treated, and this so effectually that the severest tests have been applied to the coins with impunity. It will require, however, a study of the voluminous correspondence, printed in the appendix to the first annual report of the Deputy Master of the Mint, to understand fully the vexatious nature of the difficulties arising from this source, which are now completely remedied.

WHAT IS STEEL? *

BY ANGUS MACPHERSON, C. E.

From "The Mechanics' Magazine."

It is only when we know a subject thoroughly that we can come to a positive decision upon it, and we know so little even yet of steel that we are continually changing our answers to the above question, which appears to be one of the simplest that could be asked. As a student, he would have answered readily enough: "Steel is a carburet of iron, most probably composed of 20 equivalents of iron and 1 of carbon; as the combining equivalent of carbon is 6, and that of iron 28, there are present in steel 6 atoms of carbon to every 560 atoms of iron, *i. e.*, steel is iron carburized to the extent of rather more than 1 per cent." This theory, however, has not been found to stand the test of practical experience either in the foundry or in chemical analysis, which, instead of giving the foregoing elements, shows the most variable results. Instead of returning the probable combining equivalents of iron and carbon, it steered as wildly wide of the theoretical proportion of carbon as to range from 0.25 to 1.25 per cent. This aroused the suspicion that the chemical action was more an impregnation of the iron by carbon, than an actual proportional combination—an impregnation of the iron, as it were, in a carbon bath, as in cementation, where the two elements are supposed to be chemically cemented by the operation.

Then there appeared another fact. It was found that steel could be made without carbon at all, and so could no longer properly be denominated a carburet of iron; that term must henceforth be restricted to carbon steel alone, for iron can in like manner be impregnated with silicon, titanium, chromium, cyanogen, tungsten, etc. Nay even with the supposed hurtful elements of sulphur and phosphorus, so as to have all the distinctive properties of steel, with slight variations, of course, according to the nature of the qualifying substance.

Thus far, then, the question may be answered, iron is the general and steel the specific form of the metal. Steel is merely iron steeled or hardened, by being chemically impregnated with carbon, silicon, titanium, or any of those elements which possess more or less the hardening property; chemically impregnated, as the iron does not lose its special qualities, which it would do if the two elements were proportionately and chemically combined so as to form a new compound substance. There is, of course, a definite proportion of the chemically impregnating element, which confers the greatest amount of steeling or hardening property, entitling it so far to be called pre-eminently steel-iron, or simply steel, variations from which proportion cause the metal to vary in respect of this property of hardness. According to this view we may regard ordinary cast iron as impregnated with too much, and wrought iron with too little carbon, in both cases falling short of its strongest form, steel; or cast iron is a mixture of antagonistic steel and wrought iron, which is a very mild form of steel. Thus iron, which, in its pure, simple state, is comparatively soft, is chemically toned by carbon, silicon, or any one of the other elements used in forming steel. This toning may be underdone or overdone, or the different tonics may be all mixed up together, and so modify or neutralize each other's tonic influence. The same toning or hardening influence is to be found in the vegetable world, where we find silicon toning the strength of plants, as, for instance, in the straw of cereals, which is more or less stiff and hard in proportion to the prevalence of silicious constituents in the soil on which it is grown; the length as well as the quality of the straw being influenced thereby.

The Bessemer process demonstrates distinctly the fact that there is no definite boundary between the 3 forms; that the percentage of carbon can be very gradually decreased from 1.25 per cent. to a percentage scarcely appreciable in practical analysis, without altering the essential properties of the steel, except in lessening the degree of hardness. As the greater the percentage of carbon, up to a certain point, the harder is the metal, so the

* From a paper read before the London Association of Foremen Engineers.

substitution of a harder impregnating element may be expected to produce a still stronger quality of steel, as, *e. g.*, with silicon; or the substitution of a softer impregnating element may be expected to produce a weaker quality, as with phosphorus, and this really seems to be the case. Carbon steel, however, is the kind in general use, and the only one whose qualities have been subjected to practical investigation. I shall, therefore, restrict my remarks to it. It is not only the proportionate amount of the carbon with which it may be impregnated that determines the hardness of the steel; for the same metal can be tempered, or have its hardness moderated.

Crystallization plays a necessary part in imparting the steeling or hardening property. This is obvious in the practice of hardening steel by plunging it suddenly into cold water, by which it can be rendered so hard as to be capable of scratching glass. So also, on the other hand, an extreme degree of hardness may be reduced to almost any degree of softness by heating the steel. All the gradations are beautifully marked on the bright steel in deepening rainbow tints, guiding the manipulator by visible signs as to the relaxing temper of the metal.

The first tinge of yellow indicates that the steel has barely begun to soften, though it has materially increased in toughness. As the yellow deepens towards orange, the color indicates the degree of temper required for such articles as razors, penknives, and tools for turning, planing, chipping, and boring.

As the orange deepens, the color indicates a temper suitable for joiners' edge-tools and table-cutlery. When the changing color runs into blue a temper is indicated that fits the metal for springs, and when it has completed the revolution and arrived at the color from which it started the metal has become nearly as soft as before it was hardened.

It is pretty evident the relaxing temper of the metal is associated with a chemical action of the heat on the crystalline molecules of the iron. This action is, as yet, not very well understood. It depends not only on the nature of the crystallization of the iron, but probably also on the determination of the axial direction in which the crystals are formed. Only the finest iron is used in making good steel, and the purer the iron the larger the crystals, but the quality of the steel depends also greatly on the amount of carbon, and the chemical admixture of a foreign element reduces the size of the crystals.

The finer the steel the closer will be the grain of the fracture. This brings us to another phase of the question, What is steel? It may come before us in another form. How can steel be identified? How can its varying qualities be distinguished? This is the practical bearing of the question for those who have to realize it by inspection, and on correctness depend very important consequences. Supposing a piece of steel to be submitted for inspection, how can we test its character? If it be a steel rail, it ought to contain $\frac{1}{2}$ per cent. of carbon. If it be a mild steel casting, it ought to contain about $\frac{3}{4}$ per cent., and if it be a piece of hard cutlery, about $\frac{1}{4}$ to $\frac{1}{2}$ per cent.

Of course the most correct estimate would be formed by analyzing the steel chemically, but that cannot be resorted to in the rapid turn-out of a factory, to any great extent. The nearest practical approximation to this is to dissolve a small piece of the steel in an acid, when the differing shades of brown will indicate the inherent proportions of carbon. Steel may also be tested as to its proportionate quantity of carbon by ascertaining its specific gravity, as the greater the proportion of carbon the less dense will it be found to be. The readiest method of testing the quality of steel is by examination of the fracture in a microscope. This requires considerable experience and a very powerful instrument. The unassisted eye may make a tolerable guess, but the result cannot be relied upon. Not so, however, where its power is multiplied by the powerful lens of a microscope. The crystals are found then to be octohedral, presenting the form of a double pyramid, joined base to base. As the carbon decreases, the pyramids become flatter, from the cubical form in cast iron down to the flattened form in wrought iron, which confers upon it greater capacity of being welded, and thus producing fibre. Between these extremes may be found a graduated series of pyramidal forms more or less elevated, according to the quality of the metal. If

the steel shows under the microscope a regular and parallel crystallization (which may be pretty accurately ascertained if the fractured metal be held against the light), flashing back to the eye an uniform lustre, like evenly serried needle points, the steel is of good quality. In proportion as it departs from this standard and shows groups of crystals whose discal directions are not parallel, causing the needle-like fragments of crystals to reflect a lustre patched here and there with shade, imparting to one portion a bright silvery tone, and to another a dark gray one, the metal is of inferior quality or make. Fineness and parallelism of grain can be produced by repeated melting, heating, or hammering, when cold or at a dull red heat. Cold hammering has the effect of producing an extremely fine grain.

A more correct estimate of what steel really is has had the effect of materially shortening the process of manufacture. The material itself has been made for upwards of 2,000 years, but only now, in the latter part of this wonderful century, has its manufacture been developed so as to show its capabilities. Only the practical appliances of these modern times could master the conditions necessary to simplify its manufacture. No process can be more direct than that of Bessemer; its only drawback is the very limited quality, and therefore quantity, from which proper material can be drawn. The great mass of our pig iron, in its present impure condition, is totally unfit for the Bessemer process. The pig iron must not contain less than 1 per cent., nor more than 2 per cent. of silicon. The percentage of carbon may be as high as possible, but must not be less than 3 per cent., and it makes no difference whether it be combined or uncombined. The percentage of manganese should not be more than 3 per cent., because, having a greater affinity for oxygen, a very violent action ensues in the converter, when the percentage is higher, causing explosions, and ejecting the metal. Silicon counteracts this, so that if the percentage of silicon be in excess, each unit of percentage will work quietly with 2 per cent. extra of manganese. Sulphur, phosphorus, and copper are limited to 0.05 per cent. at the most—of all these phosphorus forms the most formidable excluder. The average percentage of phosphorus in Weardale iron is 1.10; in the iron of the Forest of Dean, 0.137; of South Staffordshire, 0.41; of South Wales, 0.49; Bowling, 0.51; Derbyshire, 1.0; North Staffordshire, about 1; and Cleveland, about 1.25. This limits the selection of pig iron for the Bessemer process to about 1,000,000 out of the 8,250,000 tons of iron that Europe is estimated to produce annually. About $\frac{1}{5}$th part of the pig iron produced in this country is suitable for the Bessemer process.

The next great stride in the direction of improvement seems to be the purification of the iron. Several projects for accomplishing this are competing for public favor, but as yet none can be said to have succeeded.

The importance of the question—what steel is—cannot be fully realized without some statement of the enormous advantages to be derived from its use. Its superior qualifications have never been more practically and thoroughly set forth than in the following quotation:

"Vessels of a large size, constructed to class A 1, 12 years at Lloyd's, weigh, when built of iron, about 12 cwt. per ton measurement, whereas similar vessels, built of steel, weigh only 7 cwt. per ton of measurement. Thus an iron ship to take 1st class at Lloyd's for 1,000 tons measurement would weigh 250 tons more than a steel one of the same class."

A steel vessel, therefore, would take 250 tons, or 25 per cent. more freight at the same cost, or could avail herself of the difference of immersion to leave or enter port when the tide would not permit an iron vessel to do so. As a steamer she would carry 250 tons more of coal, and thus be enabled to lengthen her voyage, or take her coals for the return trip, or a part of her superior capacity could be devoted to increased weight and power of engines, and consequent increase in speed. In fact, just as wrought has superseded cast iron, wherever toughness and strength have been specially required, so cast steel is fast superseding wrought iron, and the measure of its use is only limited by the peculiarities of the process required to be used. The peculiar toughness of steel, and its strength and power of resisting wear and abrasion, in the form of steel rails, has developed a power of endurance as much as 20 to 1 in excess of that of

wrought iron. These qualities fit it peculiarly for crossing rails. The tensile strength of steel from which these are made is about 32 tons per sq. in., being as hard as the best chilled iron, besides not being liable to chip. Of course the tensile strength itself varies according to the hardness or softness of the metal. With the increase of the percentage of carbon it becomes stronger, until with a combination of about $1\frac{1}{4}$ per cent. it is capable of resisting a strain of about 69 tons per sq. in. Beyond this, however, the metal becomes gradually weaker until it attains the nature of cast iron, which in its weakest and softest form has a tensile strain as low as 6 or $6\frac{1}{2}$ tons per sq. in.

The inestimable advantages of steel being thus obvious, there is no wonder that the demand for it is increasing. Great advance has been made in its manufacture within the past few years, since Mushet and Bessemer introduced their processes. Upwards of 6,000 tons of steel can be produced weekly in England alone, which is more than 15 times the entire production of cast steel in Britain before the introduction of the Bessemer process, which has also cheapened cast steel by at least £20 per ton, thereby involving a saving of £6,240,000 per annum. There are favorable indications of a practically unlimited manufacture of the metal by a simplified process which will render it cheaper still, so that the time is not very far distant when the steel-iron bone and sinew of the moving powers of the world will be so tough and strong that they will be found never to fail under the ordinary condition of things.

CURVES UPON RAILWAYS.

From "The American Railway Times."

The resistance offered by curves to the motion of a railway train depends upon the length of the radius, the gauge of the road, the elevation of the outer rail, the form of the rolling surface of the wheels, the arrangement of the mechanism of the cars and engine, and upon the speed and length of the train. To obtain some guide for comparing lines with different systems of curves, or to be able to equate for curvature, we require to know as near as may be the general effect of curves upon the resistance to motion. The facts observed are quite discordant, owing to the great variety in the condition under which experiments were made.

In equating for grades we find first the ascent consuming an amount of power sufficient to haul a train 1 mile upon a level, or the grade of double resistance. So, too, in equating for curves we require the amount of curvature necessary to consume an amount of power sufficient to haul a train 1 mile upon a straight line. It is generally assumed that the resistance from curvature is inversely as the radius; that is, that we meet with the same resistance from curvature in running 1 mile of 2 deg. curve that we do in running 2 miles of 1 deg. curve. The number of degrees of curvature is the same in both cases. The total resistance depends upon the whole number of degrees traversed, and is independent of the radius or the length of the curve. This, however, is the mere theoretical aspect of the question. As a matter of practice, we are much more concerned with the momentary resistance than with the total resistance. We may distribute 1,000 deg. of curvature in such a manner over 100 miles of road that it shall be practically inappreciable ; while, if the same total amount of deflection was put into a number of sharp reversed curves, they might affect the capacity of the road to a very material extent. In equating for curvature, therefore, as in the case of grades, any rule for proceeding must be employed under the guidance of experience and common sense.

The average of numerous experiments would seem to show that the resistance upon a 10 deg. curve, or a curve of 574 ft. radius, at a speed of 20 miles an hour, is double that upon a straight line. In traversing, therefore, a 10 deg. curve a mile long we should consume an amount of power sufficient to haul a train 2 miles on a straight line. The length of a whole circle of 10 deg. curve is $574 \times 2 \times 3.1416$, or 3,606 ft. ; and this contains 360 deg. The proportionate number of deg. in a mile, or 5,280 ft., is 527, which is thus the number of deg., whatever the radius, consuming an amount of power

which would haul a train 1 mile on a straight and level road at 20 miles an hour ; and this is therefore the equating number for curvature, just as 24 ft. is the equating number for the comparison of grades at the same speed. But, as in the case of grades, a double expenditure of power does not involve a double cost of transportation. We, however, increase the cost of operation more in doubling the resistance by curvature than we do in doubling it by grades ; since the effect of curvature upon the wear and tear of engines, cars, and track, is greater than that of grades. Taking the operation of the 1,500 miles of railway in Massachusetts as a basis, and adding for a double expenditure of power required by curves 25 per cent. to the cost of repairs of the roadway, engines and cars, and 100 per cent. to the cost of fuel, we shall increase the whole expense of operating and maintaining the roads by about 25 per cent. If, therefore, a mile of road containing 527 deg. of curvature demands the exertion of double the power required upon an equal length of straight line, and if the exertion of a double power involves 25 per cent. more expense, the number of deg. consuming an amouns of *money* sufficient to operate and maintain 1 mile of road will be 4 times 527, or 2,108 deg. ; which is thus the equating number for curvature at a speed of 20 miles an hour. This number, however, being based upon a double resistance, will vary according to the actual resistance upon a straight line'; and thus according to the speed, as shown in the following table, in which column 3 gives the radius of the curve upon which the resistance is double that upon a straight line ; column 4, the corresponding number of deg. of deflecting in a mile ; and column 5, the equating number in degrees.

Speed in miles per hour.	Resistance in lbs. pr. ton.	Rad. of curve of double resistance.	Corresp'ding No. deg. per mile.	Equating No. in degrees.
15	9.3	636	476	1,904
20	10.3	574	527	2,108
25	11.6	510	593	2,372
30	13.3	444	681	2,724
40	17.3	342	884	3,536
50	22.6	261	1,159	4,636

The radii in column 3 are made inversely to the resistances in column 2, and the number of deg. in column 4 are found by the proportion—Length of circle (col. 2) : one mile : : 360 deg : No. column 4. The final numbers are 4 times those in column 4.

Thus, if we have two lines one 100 miles long with 4,216 deg. of curvature, and the other 98 miles long with 8,432 deg. of curvature, the equated distances would be :—

$$100 + \frac{4216}{2108} = 102$$

$$98 + \frac{8432}{2108} = 102$$

If we assume the cost of operation to be as the equated length, we may compare different routes by adding in each case the cost of construction to the operating expense of the equated length capitalized.

In arranging the grades upon any route, we may often so oppose the lightest ascent to the heaviest traffic that the resistance shall be the same in both directions ; but a curve does not admit of being adjusted to a traffic preponderating in one direction ; since the resistance is the same in whichever way we traverse it. We may in some cases combine the sharper curve with the easier grades, and the larger curves with the steeper grades, so as to establish a somewhat uniform maximum or ruling resistance upon the road ; but generally the same natural features that demand steep grades require at the same place sharp curves.

If we would make the resistance upon any system of grades and curves uniform, where a curve occurs upon a grade we should flatten the latter to an amount sufficient to compensate for the resistance caused by the curve. We have assumed a 10 deg. curve to cause a resistance equal to that caused by a grade of 24 ft. per mile; in which case 2.4 ft. per mile per degree of curvature would be the flattening upon the grade that the resistance may be uniform.

The following table shows the amount of flattening required upon grades for curves of different radii, the speed being 20 miles an hour, R being the radius of the curve in feet, and F the flattening of the grade in feet per mile.

R.	F.	R.	F.	R.	F.
5,730	2.4	819	16.8	442	31 2
2,865	4.8	717	19 2	410	33 6
1,910	7.2	637	21.6	383	36.0
1,433	9 6	574	24.0	359	38.4
1,146	12.0	522	26.4	338	40.8
955	14.4	478	28.8	320	43.0

At different speeds, the numbers would of course vary, as the resistance depends upon the velocity; thus the following cannot be adapted to all classes of trains upon a road, but it should be made as nearly as possible to suit the average requirement. Upon the Pennsylvania Railroad the grade was reduced at the rate of $1\frac{1}{2}$ ft. per mile per degree of curvature, or 9 ft. for a 6 deg. curve. Upon Mr. Ellet's Mountain Top Track in Virginia, it was found that with a 6-wheeled connected tank engine, weighing 50,000 lbs., a difference of 58 ft. per mile between the grade adopted on a straight line and that used on curves of 300 ft. radius, was not sufficient to compensate for the increased resistance due to curvature. The result, however, with an engine better adapted to curvature would be different. The immense 40 ton 8-wheeled connected engines upon the Lehigh Valley road, with the Bissell truck, traverse sharp curves with great ease. Upon the Central Pacific Railway the grades have been reduced from 2 to $2\frac{1}{2}$ ft. per mile per degree of curvature on curves of from 2 deg. to 9 deg. of deflection. On the Baltimore and Ohio Railway the 116 ft. grade was reduced to 110 feet upon curves of 600 ft. radius, and is increased to 121 ft. upon curves of 1,000 ft. radius.

From what has been said, it may be seen how inportant it is to guard against the introduction of grades and curves without carefully considering their cost.

When the Pennsylvania road was built a mile of distance saved was reckoned worth \$53,000 ; or \$10 a foot. If a road costs \$40,000 a mile, and the cost of maintenance and operation is \$10,000 a mile, we might pay \$206,666 to shorten the line 1 mile ; or according to Mr. Haupt's method, if the expenses which increase with the length of the road amount to \$1 per train mile, with 10,000 trains per annum we should have a capital of \$166,666; with 20,000 trains a year, a capital employed of \$333,333, and so on; showing a very rapid increase in the amount to be spent in shortening a line as the amount of work to be done increases. In estimating the amount to be spent in reducing grades or curves, we are of course to regard the effect of these elements upon the cost of operation in the same manner as above stated in the case of simple distance ; but the interest upon the cost of *construction*, which applies to *distance*, does not apply to grades or curves. Thus, while 162 ft. of ascent, or 2,108 deg. of curvature, might be regarded as equivalent to a mile of distance in the matter of operation, they are less objectionable by the amount of interest upon the cost of building a mile of road.

It may not, though, be advisable, in most cases certainly *is not* advisable, to make so great an outlay at the commencement of construction as the above figures would indicate. After a road has been brought into good condition, when the traffic has become well established, and attention is given to obtaining the greatest economy of operation, the minor faults of location which, with a new and rough road and an undeveloped business, were not appreciated, make themselves felt, and thus point out the way for bringing the line into a state of greater efficiency.

A prospectus has been issued of the British and Foreign Tramways Company (Limited), with a capital of £500,000, in shares of £10, of which £300,000 is to be first subscribed. The Company has been formed by the parties who have been principally instrumental in the introduction of tramways into this country and the chief cities on the Continent, and they propose to devote their experience to the acquisition of such concessions as may seem to present the essential conditions of success. Arrangements have already been made for taking the Brussels and Madrid lines, of which the former has been 2 years in operation, and the latter is on the eve of completion.

Utah Southern Railroad.—The laying of the rails of the Utah Southern Railroad has been commenced. Brigham Young drove the first spike, in the presence of a large concourse of spectators.

TURBINE FLUID-METER.

From "The Mechanics' Magazine."

Fig. 2.

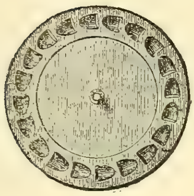


Fig. 1.

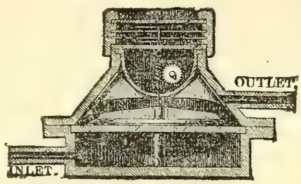
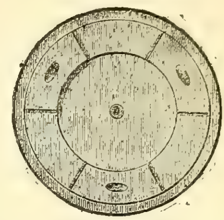


Fig. 3.



In the course of our duties as professional journalists, it has fallen to our lot to examine a considerable number and variety of fluid-meters. None of those, however, that we have hitherto seen, equal in simplicity of construction, and consequently in directness of action, that shown in the accompanying engraving, which is the patented invention of Messrs. Cook & Watson.

In our illustration, Fig. 1 is a section of the meter, Fig. 2 being a plan of the turbine disc, and Fig. 3 a plan of the plate which covers the lower compartment of the meter. From the sectional view it will be seen that this meter consists essentially of 4 parts. These are—the lower compartment, the turbine or moving part, the body, and the registering apparatus. The inlet opens into the lower compartment, which is fitted with a dished strainer, through which the water flows upwards, by the 3 oval and oblique holes in the covering-plate (Fig. 3). After passing through these holes, the water strikes against the turbine disc, the pressure slightly raising it, and impinging against the recesses in the disc, imparts to it a rotatory motion, more or less rapid according to the velocity of the water, which leaves the meter by the outlet above and on one side of the machine. The registering mechanism consists of worm-wheel gearing, actuated from the turbine spindle, and boxed off from the body of the meter.

It will be seen that as there is only 1 movable part in this meter—the turbine plate—floating freely on the fluid, friction is reduced to a minimum. When the meter is not in use, the turbine plate rests upon the bottom plate, thus preventing the return of the fluid which has passed through it, and been registered. The meter has been well tested by Mr. Simpson, the engineer to the Chelsea water-works, who reports that, notwithstanding variations in pressure, it registers correctly.

Messrs. Pontifex & Wood also have tried numerous experiments with this meter, with pressures varying from 8 to 80 ft. head of water. Their recorded experience is that the greatest deviation from accuracy was less than 1 per cent. The offices of the Company by whom it is being manufactured, are at 37 Cursitor street, Chancery lane, where these meters can be seen at work. There can be no question as to the mechanical simplicity and accuracy of this apparatus, which, combined with its cheapness, render it decidedly the best meter we have yet seen.

Robbin's method for the preparation of oxygen gas without the aid of heat has been modified by Böttger, and is represented as affording a pure gas as readily as hydrogen can be made from zinc and dilute sulphuric acid. He takes equal weights of peroxide of lead and binoxide of barium, in a tubulated retort or flask, provided with a safety tube and pours on weak nitric acid ; the evolution of oxygen takes place regularly, and the reaction is explained as follows :—Binoxide of hydrogen is first formed, and this is at once decomposed by the peroxide of lead, and pure oxygen is liberated. The mixture of the dry lead and barium salt will keep in a well-stoppered bottle, and thus the necessary reagents for the evolution of oxygen can be always on hand.

INDIA RUBBER versus IRON TIRES.

From "The Engineer."

If the Royal Agricultural Society's judges and engineers had carried out no other experiments than those which on Saturday last they conducted to a happy termination, in the sense that the results are decisive, the Wolverhampton meeting would still have deserved to rank as one of the most interesting to agricultural engineers that has ever been held. A very few years since, Mr. Thomson, of Edinburgh, patented for the second time the application of india-rubber to the road wheels of traction engines, and he had 1 or 2 engines built under his patents by Messrs. Tennant, of Leith. After a little these engines emerged from oblivion, and various paragraphs appeared from time to time in the columns of the provincial press narrating wonders concerning them. At Oxford last year india-rubber tires were for the first time introduced to agricultural engineers generally; and although the 2 engines then exhibited and built by Messrs. Tennant did nothing in any way remarkable, they attracted a good deal of attention. Then in some mysterious way the Government took the matter up. Inquiries for india-rubber tired engines began to reach England from abroad. In short, it seemed probable that a very good trade could be done in india-rubber tired engines. It forms no part of our purpose to do more than just sketch the progress of india-rubber tires to the zenith of their fame, reached just before the opening of the Wolverhampton Show. It will suffice to say that during the 12 months which elapsed between the meeting at Oxford and that at Wolverhampton 3 eminent firms undertook the manufacture of Thomson engines. These are, Messrs. Robey, of Lincoln, Ransomes, Sims, & Head, of Ipswich, and Burrell, of Thetford ; while Messrs. John Fowler & Co., of Leeds, also adopted a modification of Mr. Thomson's plans. It is to be presumed that 3 such firms would not take up an invention unless they were certain that the thing was really good; but it does not appear, strange as it may seem, that they possessed any sound data to go upon which were not supplied by Mr. Thomson himself or by his friends. It is perhaps fair to Mr. Thomson to assume that he did not lend his authority to strengthen the statements which have appeared in various journals, to the effect that india-rubber tires could traverse any land however soft, ascend any hill however steep, or haul any load however heavy. Many of the claims set up for india-rubber tires were, in our eyes, and indeed in the eyes of all competent judges, grossly extravagant ; but a large substratum of assertion remained, the truth or falsehood of which could not be determined in the lack of actual experiments made by disinterested men. Meanwhile, Thomson's engines were made and bought, and it is not easy to say what dimensions the trade in these machines was likely to assume. It became, therefore, of the utmost importance to decide what the true value of india-rubber, as a material for engine tires, may be. No private firm could settle the matter satisfactorily, but one private firm, Messrs. Ransomes, Sims & Head, were determined that they would do all in their power to enable the Royal Agricultural Society to decide what position india-rubber should hold in future. The experiments made by the Society commenced at Barnhurst on the 1st of July, and concluded on Saturday, the 8th. Our special correspondent has already recounted the history of the Barnhurst trials. India-rubber failed utterly on wet, soft ground. It remained to determine how it would comport itself on the macadamized roads, and to this end Mr. Bramwell and Mr. Easton spent Saturday, from morning till evening, in carrying out a series of experiments, which, for accuracy and completeness, are without any parallel in the history of india-rubber tires. The results obtained are beyond cavil or question. They indisputably settle the relative merits of india-rubber and iron tires ; and, considering the great prices of the former, and the magnitude of the interest involved, they possess special and unusual value.

In carrying out Saturday's experiments, the first thing to be done was to select a road which, while fairly representing the average inclines that may be met with by traction engines, would be sufficiently steep to afford a good test of the powers

of any engine. Such a bit of road was found between Newbridge toll-gate and Tettenhall-green. In order to make all the data accurate, Mr. Easton had this road very carefully levelled on Saturday morning. Sights were taken at every 100 yards with the following results: The road was found to rise for the first 100 yards, beginning at the toll-gate, or rather a little beyond it, at the rate of 1 in 35; in the second 100 yards it rose at the rate of 1 in 20; in the third 100 yards the rise was 1 in 18; in the fourth, 1 in 22; in the fifth, 1 in 20; in the sixth, 1 in 22. Then came 33 yards rising 1 in 28; and, finally, 100 yards rising 1 in 53. The entire length levelled was just 2,200 ft., but 1,900 ft. only presented, it will be seen, any incline worth notice. The road curves gently to the left, and is partly on an embankment, partly in deep cutting through the red sandstone. In quality it was admirable, being, indeed, unusually sound, smooth, and free from ruts, or stones put down for repairs. A high wind blew the entire day, accompanied by numerous showers of rain, which dried up almost as fast as they fell; practically, the condition of the road never altered during the day—it was dry almost throughout its entire length, but not dusty. It was admitted on all sides that it was admirably suited to the intended purpose.

We have stated that Messrs. Ransomes, Sims & Head were determined to do all they could to ascertain the value of india-rubber, and to this end they brought with them to the show a pair of smooth-faced cast-iron wheels, similar in dimensions to the india-rubber wheels fitted to the Sutherland, but weighing more. It was proposed that the Sutherland should proceed to Newbridge with a proper load, and ascend the hill on her india-rubber tires first, the load being increased until, the limit of adhesion being reached, the wheels would slip, and the engine could not proceed. The particulars being noted, the engine and train were then to descend the incline, and the rubber-tired wheels were to be changed for the cast-iron wheels; the engine was then once more to be loaded and ascend the hill, the load being increased or diminished until the limit of adhesion was again reached. It will be seen that in this way the most accurate results could be arrived at, all the weights being known, and the conditions of load absolutely unchanged. This programme was interesting enough, but it was rendered still more so by the courtesy of Mr. Aveling, who sent his 10-horse engine with iron wheels to take part in the trials; an opportunity was thus afforded of comparing not only india-rubber and iron wheels, but india-rubber and two distinct varieties of iron wheels together.

About 11 A. M. the Sutherland left the show-yard drawing behind her 3 wagons loaded with pig iron and 1 portable engine. The Sutherland weighed 10 tons $6\frac{1}{2}$ cwt., of which 7 tons 9 cwt. were supported on the driving wheels. The gross load to be moved, including the engine, was 36 tons. No difficulty was encountered in hauling in fast gear this load to the toll-bar, the road being all level, or down hill. Messrs. Aveling & Porter's 10-horse engine followed close behind.

Very little time was lost in getting to work. The engine was brought up to a chalk mark on the bridge wall just beyond the toll-gate, steam was raised to 150 lbs., and the engine started, in slow gear of course, at 11.55.15. She proceeded with her train with great ease up the first 100 yards, grade 1 in 35; the second length was equally well done. At 800 ft. from the starting point, the road being a little greasy, the wheels slipped slightly, but nothing of consequence, and, in short, the summit of the incline was reached in 10 min. 45 sec. after starting ; steam was easily maintained at 145 lbs. throughout. It was evident that the engine was not fully loaded. At the top of the hill the train was parted in two. The Sutherland proceeded with 2 wagons, made a sharp turn, and descended the hill, while the 10-horse (Aveling) engine returned with the portable engine and the other wagon. Much inconvenience was caused by the crowded condition of the road in moving the engines and wagons, frequent stops having to be made for horses. One lamp post was knocked down, and 1 little boy run over by a light cart, but no serious accident of any kind took place, although 2 engines and a heavy train occupied one of the most crowded roads in Staffordshire for a whole day, surrounded by a crowd of children, who could not be kept out of the way.

As it was evident that the Sutherland had not been fully loaded in the first experi-

ment, Aveling's 10-horse traction engine was thrown out of gear and attached to the end of the train, which now consisted of 3 wagons and 3 engines, the whole weighing 48 tons nearly. The Sutherland started with steam blowing off at 150 lbs., and traversed the first 300 ft. all right. She stopped by slipping her wheels on the second 300 ft. length, the incline being 1 in 20. The portable engine was then detached and the load thereby reduced to 43 tons. With this she proceeded until the incline of 1 in 18 was reached. Up this she could not get, the wheels slipped, and so ended the experiment, which proved that the maximum tractive force which the india-rubber tires would permit the engine to exert would suffice to take something more than 36 tons, and something less than 43 tons up an incline of 1 in 18. The limit of adhesion may be taken as reached with a load of 38 tons.

The next step was to bring the train back to its old quarters at the toll-gate. The 10-horse engine went to the assistance of the Sutherland, and what might have proved to be a very serious accident took place. As will be seen in our impression for June 30th, the Sutherland was fitted with a fly-wheel near the ground at the back. In parting the train the 10-horse engine unfortunately pushed a wagon against this fly, then revolving rapidly. The fly immediately flew into a hundred pieces, some of them cutting up the road right and left. Fortunately there was no one close at the time, and no harm was done. The wheel was not wanted on the road, and should have been removed beforehand. After this little episode the train was re-made up as before, with this difference that Messrs. Aveling & Porter's 10-horse power engine was substituted for the Sutherland, which returned to the toll-gate to have the wheels changed. The new engine weighed 11 tons 4 cwt. 3 qr., or nearly 19 cwt. more than the Sutherland. The total weight on the driving wheels—which are 6 ft. high and of cast-iron, rising 1 in. in the centre of the rim, which is fitted with a middle ring and diagonal crossing pieces, and is 18 in. wide—was 8 tons $10\frac{1}{4}$ cwt., or 1 ton 1 cwt. 1 qr. more than that on the drivers of the Sutherland, which were besides only some some 5 ft. high.* The engine started easily on the first 100 yards with 3 wagons, but she did not obtain her full load until the portable which had been left standing in the road was coupled on at 500 ft. from the starting point. The load was now precisely the same as that taken up by the Sutherland, plus 19 cwt. extra weight of the engine. A start was now made in fair style, and the engine proceeded tolerably well, slipping a good deal, until the 1,600 ft. point was reached. The incline here is only 1 in 22, and the engine had already managed to get over 1 in 18. But here she stuck, evidently because the wheels had been worn bright by constant slipping. The jack-in-the-box gear gave trouble, too, as it was impossible to keep both drivers revolving together. Mr. Aveling dexterously got over this point by putting a cold chisel into the compensating gear, with this result that the engine then slipped both wheels instead of one; cinders, gravel, old bricks, etc., were thrown under the wheels, and, after a hard struggle, the engine at last hauled its load to the top of the incline, having occupied, in doing a distance 500 ft. less than that traversed by the Sutherland, 29 min. 15 sec. If the iron-wheeled engine had gone over the whole distance worked by the india-rubber engine it would have occupied 40 min. Although the 10-horse engine got up the incline once, it is certain that it could not have got up the second time, as having brought the train to the bottom of the hill, she was unable to turn it into position owing to the slipping of the wheels.

By this time the Sutherland's change of wheels had been effected. It was judged expedient to begin with a light load. The wheels weighed 26 cwt. each, against 15 cwt. each for the india-rubber. The weight for adhesion was, therefore, greater with the cast-iron wheels. The load selected, however, consisted of 2 wagons and the portable engine, the gross weight moved being only 28 tons 4 cwt. With this the engine proceeded to ascend the incline with difficulty, but got on by the constant use of gravel thrown under the wheels. The 1,500 ft. mark was reached—1 in 18—but beyond this point nothing would induce the engine to ascend

* The position of the engines on the incline slightly augmented the weight on the driving wheels by throwing the water further back in the boiler and the tender, but inasmuch as they both lost 1-18th of their whole weight when standing on an incline of 1 in 18, we have not thought it necessary to use any other figures than those obtained at the weigh-bridge.

—not even coal sacks thrown under the wheels. The portable engine had to be detached, and the Sutherland reached the top with but 2 wagons, in 28 min. after starting. No more conclusive proof of the superiority of the india-rubber tired wheels was necessary. The day was far advanced, and so the experiment terminated with the return of the wagons and engines to the show-yard.

Let us see what are the deductions to be drawn from these experiments. They are—(1) India rubber tires may be depended upon to take with certainty a gross load equal to 5 times the insistant weight on the drivers on a level up inclines of 1 in 18 on good roads; (2) cast-iron tires with cross ribs and narrow central bearing rings, which are found to give more adhesion than wide wheels, cannot be depended upon to take more than 3.75 times the insistant weight on the drivers on a level up an incline of 1 in 18; (3) smooth cast-iron drivers 5 ft. diameter, and broad in the face, cannot be depended upon to take as much as 3 times the insistant weight on the drivers on a level up inclines of 1 in 18; (4) the adhesion of both forms of tire is greatly reduced by the polish imparted to the wheels by slipping; (5) this does not seem to apply to india-rubber tires, the bite of which is apparently a constant quantity, irrespective of polish in the chain; (6) on hard roads the friction between the wheel and the rubber is slightly greater than the friction between the tire and the road.

As regards the coefficient of friction, it is not very easy to arrive at a definite conclusion. The resistance due to gravity of a train weighing 36 tons, and starting on an incline of 1 in 18, is 4,480 lbs. Assuming the resistance due to road friction to amount to 40 lbs. per ton—and in this case it could not have been less—we have a gross resistance for the engine and train of $4{,}480 + 1{,}440 = 5{,}920$ lbs. The load on the drivers standing on an incline of 1 in 18 amounted in the case of the Sutherland to 15,868 lbs. This, divided by 5,920, gives a coefficient of $\frac{1}{2.7}$ for the work actually done by india-rubber tires. About the Aveling engine it is yet more difficult to speak. Not only is there room for doubt as to the actual road friction resistance, but there is also a doubt as to what is admissible in the way of slipping. Assuming that Aveling's engine got up just as well as the Sutherland with 37 tons gross load, we have 5,984 lbs. as the gross resistance; and this divided into the gross load on the drivers, amounting on an incline of 1 in 18 to 17,982 lbs., gives as nearly as possible 3 as a quotient. Therefore the coefficient of adhesion of cast-iron tires would be $\frac{1}{3}$. But as a matter of fact the 10-horse engine only got up the incline with the aid of sand, cinders, and broken bricks and stones. The engine had to be detached from the train at one place to enable her to get on new ground, a long chain being used to connect the two. Besides, as the wheels become brighter and brighter, they had less and less adhesion. Under the conditions, we believe it would be wrong to assume that the coefficient of adhesion is greater than $\frac{1}{4}$ of the insistant load, provided no sand or other means of obtaining adhesion be used. The coefficient of smooth iron wheels is very much less, but no data are supplied by the experiments of Saturday, going to show precisely what it is.

Professor Wagner, in his reports, says that the manufacture of iodine from Chili saltpetre already amounts to 30,000 lbs. per annum. The method invented by Thiercelin for its reclamation from the crude material is as follows :—The mother liquors resulting from the manufacture of saltpetre are treated with a mixture of sulphurous acid and sulphite of soda, in proper proportion, and the iodine will be precipitated as a black powder. The precipitated iodine is put into earthen jars, on the bottom of which are layers of quartz sand, fine at the top and coarse at bottom; from this it is removed by earthen spoons into boxes lined with gypsum, and a greater part of the water thus removed. It is sometimes sold in this impure state, or further purified by sublimation.

At the Upper Forest Tin Works, near Swansea, Messrs. W. Hallam & Co. have rolled the thinnest sheet of iron ever produced. It requires 4,800 such to make an inch in thickness.

The fourth volume of the "Coal Plants of the Illinois Geological Survey" embraces descriptions of 78 new species.

NARROW GAUGE RAILROADS.

By HORATIO SEYMOUR, Jr.

In a report upon narrow gauge railroads, read before the British Association by Mr. Fairlie, he says: "It ought to be engraved upon the mind of every engineer, that every inch added to the width of a gauge beyond what is absolutely necessary for the traffic, adds to the cost of construction, increases the proportion of dead weight, increases the cost of working, and, in consequence, increases the tariffs to the public, and by so much reduces the usefulness of the railway." He further adds: "In moderate, temperate climates, gauges of 2 ft. 6 in. will be found ample for any traffic in any part of the world, and will sustain a speed of 30 miles an hour; while 3 ft. is sufficient for either very hot or very cold climates, and will sustain a speed of 40 miles an hour."

The author then went on to make a comparison between the North Western Railroad of England, the best managed road in the world, as it now is, a 4 ft. $8\frac{1}{2}$ in. gauge, and what it would have been had it been made a 3 ft. gauge, proving that there would be a saving of $\frac{1}{2}$ in the expenses of running the road.

I apply the same reasoning to American railroads, both as to the making and running them.

I take the 3 ft. gauge, both because of the severity of our climate, and because the time that can be made on it compares favorably with the time made on our fastest roads.

The chief difficulty of building railroads is their cost; and this difficulty hinders the making of roads which would pay well if they were built.

It is rarely that we find a road being built and equipped for less than $33,000 or $34,000 per mile, a rate at which a road 30 miles long would cost $1,000,000; a large sum of money for a community to raise, and capitalists are not wont to invest such sums in an enterprise which, taking 2 or 3 years to complete, will only, after its running, bring them at the most 7 per cent interest.

But if we can build a road which has equal capacity with any other, both for carrying freight and passengers, upon which equally fast time can be made, for 60 per cent. of the cost of the 4 ft. $8\frac{1}{2}$ in. gauge, and its construction shall be such that after it is built it shall cost but half as much to run it, then the difficulty in raising money is in a great measure removed.

I will show that the 3 ft. gauge makes this reduction in cost, and will do so in detail.

There is a necessity for only $\frac{3}{5}$ths the amount of land now taken for right of way.

The amount of cutting and embankment to make the road bed would be but $\frac{3}{5}$ths, while the location of the narrow gauge, by running sharp curves, will cut down this, the great cost of construction, in rough countries, according to English engineers, to about 25 per cent. of the cost of the 4 ft. $8\frac{1}{2}$ in. gauge.

The width of the bridges and culverts may be diminished in the proportion of 3 to 5.

The ties may be shorter.

The rail will weigh but 37 lbs. to the yard, in place of the 70 lb. rail now in use. The 37 lb. rail is now used on 2 narrow gauge railroads in Sweden.

The locomotive may be made to weigh between 6 and 20 tons, in place of the 20 to 40 ton locomotives now in use.

The cars not only may be but $\frac{3}{5}$ths of the size of the cars on the broader gauge, but they may be made lighter in every way.

Buildings may be made much smaller, though the reduction in cost may not be as great as $\frac{2}{5}$ths.

Turn-tables may be smaller in the same proportion.

The time required to build the road will be shortened $\frac{2}{5}$ths, and thus give a quicker return for the money invested.

The cost of supervision will be less in proportion.

We have seen that on a road of 3 ft. gauge, the right of way, the culverts and bridges, ties, rails, and locomotives, turntables and cars, interest on investment, and cost of supervision, would all be reduced $\frac{2}{5}$ths; while in the cost of earth moved there would be a reduction of $\frac{3}{5}$ths; the buildings would only be reduced perhaps $\frac{1}{5}$th; giving in all a saving of $\frac{2}{5}$ths of the cost of the 4 ft. $8\frac{1}{2}$ in. gauge.

Experience has proved the statement to be true. A Russian commission certified to it. In Norway, 2 railroads of 3 ft. 7 in. gauge were constructed by Mr. Pihl; one at Storen, and the other at Hamar; the Hamar line cost £3,000 per mile, the Storen £5,000 per mile; during the building of these roads, and within a few hundred miles of them, a road was built on the 4 ft. $8\frac{1}{2}$ in. gauge, the rate of wages being the same on the 3 lines. The 4 ft. $8\frac{1}{2}$ in. gauge road cost £6,400 per mile, thus showing a saving in the case of one of the narrow gauge roads of £1,400 ($7,000) per mile, and in the other of £3,400 ($17,000) per mile, an average saving of $\frac{2}{5}$ths in favor of a narrow gauge, which was 7 in. broader than the one we propose.

The next point to be seen is, whether we can make good our statement that the 3 ft. gauge can carry an equal amount of freight and passengers with the 4 ft. $8\frac{1}{2}$ in. gauge, and at the same speed. The Fairlie engine upon the Festiniog Railroad, in Wales, on a gauge of only 2 ft., drew 500 tons on the level, and over the whole road, around curves of only 116 ft. radius, and on a grade of 71 ft. to the mile, drew a load of 206 tons during a trial trip made before a Russian commission. The average weight of freight trains, including freight and locomotive on the New York Central is 360 tons, according to their report of 1868.

The highest rate of speed made on the 2 ft. gauge is 30 miles an hour, but the engineer says he can make 40 with perfect safety. On the Ullinbord road in Sweden, a 3 ft. 7 in. gauge, 35 miles an hour has been run with a 12 ton locomotive.

The British Association reports say that on a 3 ft. gauge, 40 miles an hour may be run.

On the Festiniog Railroad, during the year 1868, 130,000 tons of goods and 145,000 passengers were carried. This road is only 13 miles long. In the same year the Syracuse and Binghamton Railroad, which is 81 miles long, carried 424,537 tons of freight, and 245,577 passengers.

The Black River and Utica Railroad, which is 86 miles long, carried in the same year 25,403 tons of freight, and 100,111 passengers.

The Ullinbord Railroad, in Sweden, which is 23 miles long, of 3 ft. 7 in. gauge, reports a business of 100,000 passengers, and 150,000 tons of freight a year.

The cost of maintaining a road must depend upon the amount of weight the road bed has to carry, since the cost of repairing it is as compared with all other repairs nearly 3 to 1.

The New York Central report for 1868 gives the cost for keeping up the permanent way as $3,000,000 to $1,000,000 for all other repairs.

If we can reduce the weight that a road bed has to sustain $\frac{1}{2}$, and not reduce the amount of freight, and at the same time increase the durability of all the materials composing the road, as well as the running machinery, we have cut down the cost of operating the road just $\frac{1}{2}$.

The ordinary box freight car of the New York Central weighs 10 tons, and carries 10 tons; the average number of cars in a train is 18; 18 cars weighing 10 tons each and each carrying 10 tons, would give a load of 360 tons as the average weight of a loaded train; of this 360 tons, 180 tons is non-paying weight. Taking the number of cars that run half full, and the number that run half of the way empty, may we not estimate that the Central carries a proportion of 2 tons of non-paying load to 1 of paying?

The Festiniog Railroad uses cars weighing only $\frac{1}{2}$ a ton, carrying a load of 3 tons, a proportion of 6 tons of paying load to only 1 of non-paying. John B. Jervis has built cars weighing 3 tons which carry 7 tons. The Norway roads build cars weighing 3 tons which carry 6 tons. In the case of the Festiniog road, the paying weight was as to the non-paying weight relatively 12 times greater than that of the New York Central, and in the case of the other roads it was 4 times that of the Central.

To make as safe a calculation as possible, we will say that cars can be made for the 3 ft. gauge weighing 3 tons which can carry 6. The total amount of freight or paying weight carried on the New York Central in 1868 was 1,846,000 tons; to carry this, assuming that the cars ran full both ways, an equal amount of non-paying tons (the weight of the cars) has to be drawn over the road. On the narrow gauge road, if the same amount of freight was carried, only 923,000 tons of non-paying load would have to be drawn, a saving of 923,000 tons, which the New York

Central has to carry at a dead loss. In fact the loss is twice this, as the cars are not loaded for more than ½ the distance. As it costs the road $1.58 to transport a ton, the hauling of these non-paying 923,000 tons costs the New York Central $1,458,340 a year.

There are other benefits arising from the use of small, light cars. They can be handled with greater ease. Friction, both of the rails and axles, increases directly as the weight. The jar or blow which the car receives from any unevenness in the track, or want of uniformity in the wheels, is increased by the weight.

The decrease in strain on machinery from having the points of support nearer together is immense.

So far we have been considering freight cars; the same reasoning applies to passenger cars, which weigh, on the Central, about 18 tons each, and are made to carry 50 passengers, although the average number in each is about 25. On the Norway 3 ft. road, the cars carry 28 passengers, and weigh 4 tons, while on the 4 ft. 8½ in. gauge, in the same country, the cars carrying only the same number of passengers weigh 6 tons; 28 passengers in a car weighing 4 tons would give 300 lbs. of car for each passenger. Giving 400 lbs. of car weight to each passenger, a car could be built that would carry on the 3 ft. gauge 30 passengers, and be but ⅓ the weight of the Central cars. An 18-ton car carrying 50 passengers, would give to each person 720 lbs. of weight of car; while in a 6-ton car, carrying 30 passengers, the weight per person would only be 400 lbs., a saving of 320 lbs. per man, which in a car carrying 50 passengers would amount to 16,000 lbs., which are like, it has been aptly said, so many dead-head passengers that never get out.

The great objection urged against the construction of narrow gauge railroads is, that as the main lines are all 4 ft. 8½ in. gauge, if the branch lines are of a narrower gauge, the freight must be all reshipped at a large cost. This is a disadvantage, but the amount of cost of transferring freight is greatly overestimated.

The engineer of the Ullinbord Railway in Sweden found the cost of transferring to be but 2 cents per ton, since the labor was not great when cars were placed alongside of one another.

We read every day of some 6 ft. gauge being changed to 4 ft. 8½ in., and perhaps as the world improves we shall see railroad companies consulting their interests, and changing to a 3 ft. gauge.

STONE CAISSONS.

From "Engineering."

A number of gentlemen, including in their number Gen. Strachey, Mr. Juland Danvers, Mr. A. M. Rendel, Mr. W. J. Thornton, Mr. J. Cubitt, Mr. C. Hawkesley, and others, were received at the works of the Ransome Patent Stone Company, by Mr. H. Bessemer, the Chairman, to inspect some stone caissons now being made, to be used in the construction of the quay at Hermitage Wharf, near the Thames Tunnel pier. The opinion universally expressed was favorable to this new application of the Ransome stone, but of course the test of experience must be applied before any definite conclusion can be arrived at. If, however, it should be found successful, and we have little doubt it will, this application of Mr. Ransome's stone, made under his patent of last year, to the construction of foundations for piers, bridges, river walls, and all kinds of hydraulic works, will be possessed of the most important advantages, which can scarcely be over-estimated.

The rapidity and ease with which blocks of any form, and the sizes of which are limited only by the means available for handling them, can be produced upon the spot where they are to be employed, are advantages sufficiently great to warrant their adoption. And when, in addition, it is remembered that the materials which form the base of the Ransome stone exist in most instances in embarrassing quantities upon the site where hydraulic works are carried on, and that these, by the combination of other elements, are converted almost immediately into a stone, the strength of which is surpassed only in a small degree by granite, it will be admitted the advantages obtained are almost incalculable. This application of Mr. Ransome's process

has been suggested by Mr. Butler for two reasons: the first, to provide a cheap and thoroughly efficient substitute for stone for hydraulic works; the second, to render unnecessary the construction of false works, coffer-dams, etc., and to avoid the employment of iron cylinders and caissons, now of necessity so extensively used.

In order to obtain perfectly reliable data as to the powers of resistance of Mr. Ransome's stone, a valuable and exhaustive series of experiments was recently carried out, and the result of these experiments showed that the average power of the stone to resist a crushing force was 3.19 tons to the sq. in. It should, however, in justice be remarked that this average was reduced by the fact that some of the stone blocks tested were composed of materials which necessarily gave a comparatively low result, and that the average strength of the stone manufactured in the ordinary manner, gave an ultimate strength of 4 tons per in., which may be assumed as the average strength of the stone.

Compared with some of the best natural constructive materials, the strength of the Ransome stone stands thus:

Granite, resistance to crushing, 8,000 to 12,000 lbs. per sq. in.

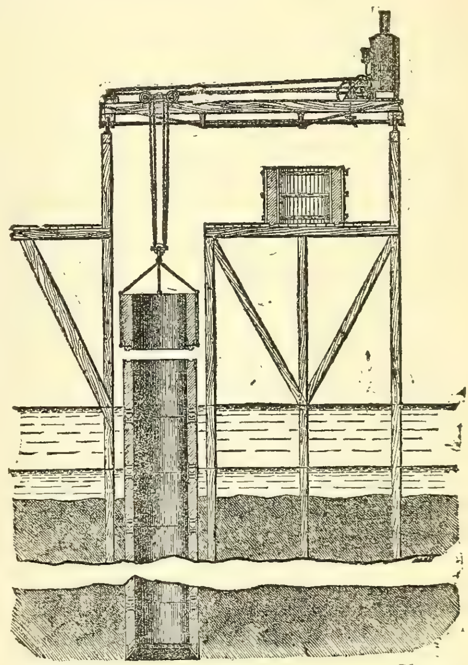
Portland stone, 2,630 lbs. per sq. in.

Bramley Fall, 5,120 lbs. per sq. in.

The Ransome stone, 8,960 lbs. per sq. in.

It will thus be seen that the Ransome stone is, so far as strength is concerned, one of the most suitable of all building materials, and being perfectly homogeneous, it is thoroughly reliable. With regard to its durability, it is sufficient to point out that its constituent elements, and the manner in which the concretion of the entire mass is effected, guarantee for it a hardness and durability scarcely to be met with in any other material, whilst its uniformity of color and texture render it also peculiarly suitable for the new purpose for which it is now being applied.

In practice, the materials forming the stone will be moulded *in situ* into blocks, either solid or cellular, of the required shape and dimensions. The cellular blocks form, however, the special peculiarity of this system. For bridge piers and abutments the blocks may be rectangular or circular, for dock and river walls they may be square or hexagonal—in fact, any required shape may be given them. If found advisable, they may be stiffened internally with iron braces, but this would be seldom necessary, as the strength of the material will be found sufficient, unless in very exceptional cases. For convenience in sinking the blocks (an operation which is precisely similar to that employed in sinking iron cylinders) the lower edge of the bottom length would be chamfered, and, when necessary, shod with iron. The horizontal joints would be made preferably with alternate projections and depressions in the sides of the blocks, and the vertical joints are made good with timbers halved into each block. But these joints may be effected in a variety of ways, which need not be specified here.



What is specially urged for this system is, that it is a simple and reliable utilization of material thoroughly adapted for the purpose, that it provides a cheap and efficient substitute for the present costly means of sinking foundations, and it is confidently believed that by its application a great revolution will be effected in the construction of hydraulic works.

It need scarcely be explained that, in nearly all cases, the stone blocks, or caissons, form their own coffer-dams, whilst

in those exceptional instances, where temporary works are required, their extent and cost would be reduced by the new system.

It is also evident that there are few circumstances under which the process described, or modifications of it, would be inapplicable, whilst its cost, even under the least favorable condition reduced to half that of the existing modes of construction, would, in situations where skilled labor is scarce, and materials and the means of transit costly, be further reduced to a far larger extent.

THE BUILDING ARTS OF RUSSIA.

From "The Builder."

Marble enters very sparingly as yet into the composition of private buildings in Russia. There was an exhibitor from Moscow who had samples of marble work, the raw material being obtained in the neighborhood of that city, and called Padolian marble, a gray species. The prices attached to the specimens were as follows: Steps, per archine ($\frac{3}{4}$ yard) in length, 5 r. s. (12s. 6d.) polished, 4 r. s. (10s.) unpolished; landing slabs, per sq archine, polished, 5 r. s. (12s. 6d.); plain, 3 r. s. (7s. 6d.). Window-sills, polished, per vershok ($1\frac{3}{4}$ in.), 1d. The finer qualities of marble (raw material) are all imported, on which there is no duty. The working of stone in Russia is effected entirely by hand labor; but there is no doubt that with the increase of the material prosperity of the country a demand will spring up for some of our machinery, which has been lately introduced for the above purpose. There is already one establishment at St. Petersburg where stone is dressed by machinery. The museum of the School of Mining sent to the exhibition specimens of jasper, porphyry, marble, agates, etc., in the raw state, obtained from Siberia; but these materials are as yet too expensive to be applied for architectural purposes, even in the houses of the most wealthy. Specimens of their application, on a large scale, for the above purposes (decorative architecture), are to be seen only in the Imperial palaces, such as those of Tsarskoye-Selo, near St. Petersburg, where the interior offers enormous treasure and splendor. There are chambers of amber, mother-of-pearl, jasper, porphyry, and agate; colonnades of malachite, mosaic pavements, etc.

Notwithstanding the abundance of malachite found in the Ural Mountains, it is rarely to be seen in the shape of doors and mantel-pieces, such as were exhibited in the London Exhibition of 1851. The price quoted for raw malachite by Mr. Demidof at the late Russian Exhibition was 125 r. s. per pood (£1,030 per ton).

No modern city can boast that it is so entirely composed of colossal buildings as St. Petersburg. The Winter Palace, for instance, has 6,000 inhabitants. In the Infantry Hospital several thousand beds are made up. In the Foundling Hospital there are many thousand children. There are single houses from which their owners derive princely revenues. The ground which is occupied by the Corps of Cadets forms a square of which each side is about a quarter of an English mile in length. There are other buildings, such as the Admiralty, the Hotel de l'Etat Major, the Gastinny Dvor and other markets,—buildings which occupy space enough for a small town. It was the custom formerly to build private houses, occupying an enormous area, no higher than 2 floors; but, with the increase of the value of land in the capital, high buildings became indispensable, so that they are now constructed from 3 to 6 stories high. The styles adopted at St. Petersburg for private and public buildings are varied. The building of a house in St. Petersburg is always done by contract, under the superintendence of a qualified architect, who is subject to the Government architect and surveyor, whose business is to watch the operation of construction. The erection of a house is a much more costly undertaking in St. Petersburg than in any other part of Russia. Provisions are dear, and the price of labor is always comparatively high. The building can only take place in the summer months, which necessitates the employment of an extraordinary

number of workmen, who engage by contract for the whole term, when the wages are paid, the contractor providing lodging and food. As a rule, the houses are well built, with brick walls, a desideratum in a cold climate. The staircases are invariably of stone ; and considering the primitive nature of the tools and appliances of the workmen, the work is rapidly executed (the hours are from 3 in the morning till 8 at night, out of which 2 hours' rest is allowed after dinner). The Russian trowel is only the size of those used by plasterers in this country, and of the same shape ; and for the batting of the bricks a separate instrument is employed, somewhat in shape like a plasterer's hammer. The spade used is of wood, tipped with iron. Nearly all the wooden appliances are knocked together on the spot, such as troughs and barrows. Of the latter, the iron wheel and axle are the only parts which are carried from place to place. Ladders are also knocked up on the spot. The bricks are carried on the back, on a kind of stand, with curved arms, which rest on the shoulders; and the mortar is trodden with the feet, to the ruination of the boots of the poor workmen. This primitive mode of contion all adds to the cost of building in Russia. The introduction of appliances and machinery, such as proper windlasses, hoists, mortar-mills, etc., would be of incalculable benefit, both to the workmen and employers, considering that building in the capital is always conducted on an extensive scale. One of the terms which is strictly enforced at St. Petersburg is the covering of every dwelling-house with stucco, which must be colored, and kept in constant repair, as the climate acts very disastrously on the appearance of the houses. Almost every spring the stucco peels and tumbles off; and nothing has so disagreeable an effect as Corinthian or Doric columns, which, in dilapidated buildings, expose in patches the red brick of which they are constructed. This is constantly to be seen in the provincial towns. Another feature of Russian architecture is the class of summer residences in the neighborhood of St. Petersburg. Every one who can afford it leaves the capital for the summer months. The poorer classes resort to the villages in the vicinity, and the rich to the country houses, called datchas. They are generally built on the banks of the Neva, and are of wood, in all manner of styles. Gothic, Italian, and even Chinese specimens are to be found, of the taste of all ages. Although they have generally cost enormous sums in the erection, and display much luxury, we should look in vain for the architectural grandeur of the Italian villas or the comfort of English country houses.

One great characteristic of the Russian building art is church architecture, of which Moscow and the ancient towns Kief and Novgorod contain remarkable specimens of what is called Russo-Byzantine style, of which one of the chief features is the towers surmounted with the cupolas in the form of a bulb or onion, not unlike those of the Pavilion at Brighton, on the top of which is a cross. With a general similarity in appearance, the form of the towers varies considerably, striking the eye by their irregularity and their diversity of colors and gilding. It is to this particular that Moscow owes its remarkable appearance. It would appear altogether that very little attention has been paid in Russia to the studying of their ancient church architecture, or archæology, generally speaking, until quite recently, when the initiative was taken by a private gentleman, Mr. Prokhorof, who undertook on his own account the publication of a work entitled "Antiquities of Christendom and Archæology." It contains, among other things, etchings of interesting specimens of frescoes of the 12th century from the Church of St. George at Staro-Ladoga or Ruric's Fort. Following in the footsteps of the above gentleman, the Moscow Architectural Society have despatched several of their members for the purpose of illustrating ancient Russian sculptural monuments, particularly in the ancient towns of Pereslavl-Zalessky, Rostof, and Yaroslaf. Photographic views are to be taken of the exteriors of the churches, from parts which have been the least subject to innovation, and of the interiors. It is the intention of the Society to form a gallery of these photographs, the first of its kind, at the forthcoming Moscow Technical Exhibition of 1872.

At the St. Petersburg Exhibition were to be seen some plaster casts of frescoes in the Russo-Byzantine style, together

with a fac-simile of the doors of an Ikonostas, or altar-screen, taken from the ancient church at Suzdal, which attracted much notice.

The church architecture of St. Petersburg differs from that of the old towns. It has neither so many nor so distinguished churches as Moscow, although the major part are built in a pleasing and tasteful style—in the modern Russian, which is a mixture of the Grecian, Byzantine, old Russian, and New European architecture.

The St. Petersburg Exhibition, in an artistic point of view, presented far more important features than the Russian department at the Paris Exhibition of 1867. Not only separate articles, but whole groups of objects, forming of themselves already complete and distinct exhibitions, appeared here with characteristic and remarkable originality. Of these, carvings in wood were particularly noticeable. The Russians are masters in wood-work, and a particular kind of artisans in the capitals, and, indeed, in all Russian cities, are the carvers in wood. It was to be expected that among the inhabitants of the immeasurable forest districts of Russia a peculiar dexterity in wood-carving would develop itself. The sculptors in wood in the towns are distinguished from the carvers of the villages, who devote themselves principally to the production of articles of domestic use; the former work to a very great extent at the ornamental parts of the interior of churches, where the Russians love to see pomp and splendor, for which an enormous quantity of wood-carving and gilding is required. For fine work the lime is chiefly used. Each workman, when engaged on a piece, has a drawing before him, working on a block of wood with chisel, knife, and hammer, and the dexterity with which he will form the whole figure from a flat picture is remarkable, considering how little he is indebted to any sort of instruction. In church decoration the most striking objects exhibited were the Ikonostases above mentioned. The Ikonostas is a high screen carved in wood and gilt, which separates the holiest of holies from the rest of the church, on which are represented images (paintings) of Jesus Christ, the Virgin Mary, the four Evangelists, and other saints. The drapery of these paintings is made in solid silver and silver gilt, raised and engraved. In the middle are the doors, or Tzar's gates, as they are called, which generally constitute masterpieces of the carving and gilding, of which a specimen was exhibited by a Moscow firm, beautifully formed of golden columns, and mixed and interlaced with vine leaves and ears of corn, richly gilt. Part of an Ikonostas in oak destined for the Russian Church of the Trinity at Jerusalem was also conspicuous. The price of the whole Ikonostas was to be over £1,000.

It is somewhat remarkable, that while various reforms are being introduced in Russia, modelled on those of Western Europe, a complete change has come over the taste in ornamental art. The Roman, Greek, and Italian French styles are being abandoned, and a purely national taste is cultivated. This was apparent at the Exhibition; in fact, may be regarded almost as a sort of fanatical patriotism, and a curious instance of this spirit was noticeable some time ago in the Strogonof School of Des gn, in Moscow (containing 200 scholars). In that school, the pupils who learnt landscape drawing were to copy nothing but Russian landscapes. Those who studied flowers were to embody in their designs Russian flowers only; while designs of a more complex character were taken from Russian illuminated missals, or other works of Russo-Byzantine art. With regard to the latter, a very interesting work has been published and executed in Paris, from the designs by the pupils of the above school, taken from Russian illuminated manuscripts, entitled "History of Russian Ornamental Art, from the Tenth to the Sixteenth Centuries." This publication should claim the attention of our own designers and architects, as being novel, and the designs applicable to the ornamental art of this country—the innumerable figured patterns and ornamentations shining in splendid colors, sometimes on a golden ground, with endless and varied plait work and geometrical figures of the most wonderful kind, all this in combination with leaflets, flowers, stalks, and twigs, and strangely intermixed forms of dragons, affording rich material for the artist and artisan. The Count Strogonof School of Design has already considerable influence on the development of native industry, and produces a large number of designers, who find ready employment in Moscow. A useful work

has just been published, entitled "A Guide for making Russian Designs."

Besides drawings and plaster casts of ancient Russian architecture, there were exhibited by the same school very fine specimens of painting on china, delf, enamelled iron, flooring tiles, etc. In the department for wood carvings, there were some fine specimens of Russian woodwork, fretcutting, with curious carving, notably the kiosk, where Bibles were offered for sale, and the pavilion containing Mr. Tatischef's collection of Russian woodwork, a case in the form of an izboushka (a little izba), containing samples of macaroni, a garden pavilion, finished with a kind of wood tissue.

As to Heating and Lighting.—In general the Russian stove is a large, clumsy, oblong mass that rises nearly to the ceiling of the room, to which it is a disfigurement rather than a decoration. It is these drawbacks that have lately been noticed by Russian builders, and in some of the modern houses a kind of compromise has been effected between the Russian stove and the English fireplace, which, as regards cheerfulness, is certainly an improvement. English fireplaces, with marble chimney-pieces and fire-irons, etc., are occasionally imported, but the duty and expenses are too high to make them a regular article of traffic. The Russian stove as at present constructed, of white glazed tiles, is, doubtless, of Dutch origin, as the shape and size of the tiles is that which prevailed in Holland about 2 centuries ago; they are clumsy in appearance, heavy, and quite unsuitable for any kind of ornamental work. At the Exhibition some of these tiles were shown: white, at from 7 copecs (2¼d.) to 15 copecs (5d.) each; and of a red color, 3 copecs (1d.) to 6 copecs (2d.) each. There is this peculiarity to be noticed in the glazed tiles manufactured in Russia—after being a short time in use the enamel invariably cracks all over, presenting a very unsightly appearance. There is another kind of Russian stove which is fast superseding the one just mentioned. It is of a cylindrical form, and is constructed of red brick, covered with sheet iron. It is cheaper than those constructed of glazed tiles, but does not retain the heat so well; and its gloomy appearance, and when the dark green color with which it is generally painted has been burnt and blistered, tends considerably to mar the *tout ensemble* of the apartment in which it is erected.

The cooking stove or *plita* used in the capitals has now almost entirely superseded the old-fashioned Russian *pech.* The former is fashioned somewhat like our kitcheners, but they have this advantage that they can be approached from 3 sides; it consists of a thick iron plate set in brick and glazed tiles, with baking oven. Taking it altogether it is a clumsy contrivance, and takes up a great deal of room. It is used for boiling, frying, and baking; appliances for roasting are not known except in a few of the elaborate kitchens of rich Russian gourmets. The pech is very much like a baker's oven, the whole arrangement being very primitive, besides consuming an inordinate quantity of fuel.

In the heating of a Russian stove, pine, fir, and birch wood are principally used; and it should be remarked that the embers play a most important part, for it is from the embers, not from the flame, that the stove is expected to derive its heat. So long as the wood continues in a blaze, whatever quantity may have been put in, the stove never gets thoroughly warm; it is only by means of the "viewshka," a sort of double flue plate, that the passage from the stove into the chimney has been hermetically closed that the heat begins to be sensibly felt in the room. The Russian stove-heaters are extremely dexterous in all the details of their occupation. Tongs and shovels are unknown to them. Their only instrument is the "kocherga," a long iron poker, with a hook at the end of it. With this they keep up stirring the fiery mass, break up the embers, and pull forward the fragments of wood that are still burning, in order, by exposing them to a current of air, to accelerate their conversion. In every great house there is at least one servant whose exclusive duty is to look after the stoves, and he collects and prepares the requisite fuel. In general he builds up a pile of logs within each stove the evening before, that the wood may be well dried, and then he sets fire to it early the next morning, using for that purpose the tarry rind of the birch. If the "viewshka," or damper, be closed before the wood be completely burnt into embers, a poisonous gas is emitted by the coals, and

fatal consequences may ensue to those who are exposed to its influence; the blue flame hovering over the bright embers is therefore carefully watched, and not until it entirely disappears is it considered safe to close up the stove. Accidents do occasionally happen, and it is nothing uncommon in Russia to hear of people who have been suffocated by the fumes of their stoves; but when the immense number of these stoves is taken into consideration, and that every floor and every part of the house has to be heated at least 6 months in the year, it must be admitted that accidents occur but rarely, and that an admirable degree of care is displayed in thus always selecting the proper moment for closing the " viewshka."

The attention of Russian specialists has lately been directed towards the discovery of means of effecting economy in fuel, which is an important and expensive item in every Russian household, the reckless manner in which woods have been destroyed causing no little anxiety concerning the future supply. When we consider that the winter lasts 6 months, and that, at St. Petersburg, where the climate, although somewhat modified on account of the proximity to the sea, the thermometer, in winter, often points to 55 deg. of Fahr., the imperative necessity for an improved state of things in this department is self-evident. At the Exhibition was shown a stove built, or rather cased in glazed tiles, with hermetical doors, adapted for burning coals, instead of wood,—a decided improvement. The price was 115 r. s. (£14 7s. 6d.). Other stoves of the same kind were exhibited by a maker from Finland, for burning wood, at from 32 r. s. to 92 r.s. (£4 to £11 10s.) each. Iron stoves, of various other constructions, were also shown; but it would appear that in no instance was it demonstrated that the main object had been attained,—the economy of fuel. There were steam-heating apparatus, hot-water apparatus, priced respectively 80 r. s. and 75 r. s. (£10 and £9 7s. 6d.); iron stoves, plain and ornamental, from 50 r. s. to 275 r. s. (£7 10s. to £37); hermetical doors, iron, per pair, from 10 r. s. to 15 r. s. (£1 5s. to £1 17s. 6d.); the same of brass, from 22 r. s. to 30 r. s. (£2 15s. to £3 15s.). As a novelty may be mentioned a portable heating apparatus, heated by means of a " pulverizing lamp," the latter consisting of an adaptation of the principle of the "pulverizer" used by hairdressers, in which the minutest particles of liquid fuel are consumed, a blast being produced by means of an air-pump, which forms part of the apparatus. The merit of this invention consists in the celerity with which water can be boiled—in 2 or 3 min.

Ventilation.—This essential condition of the sanitary economy of buildings has been ever neglected in Russia; and it is only lately that efforts are being made towards providing for this desideratum. It should be observed that the houses in Russia as early as October may be said to go into winter quarters. Double windows are affixed to every room; every aperture through which a little air might find its way is carefully caulked with tow, and then filled up with putty, or pasted over with slips of paper. Here and there a window is so constructed that a single pane may now and then be opened to let in a litte air. In this close and confined atmosphere the family live and have their being till the returning May ushers in the warm weather, and gives the signal that fresh air may again be permitted to circulate through the interior of the house. The Russians have a saying,—"*Par kostay ni lomit*,"—literally "Steam does not break bones," meaning that heat cannot be injurious. This conviction is perhaps the reason why a temperature of 15 deg. Reaumur ($33\frac{3}{4}$ deg. Fahr.) in the bedroom is in no way considered excessive or injurious. There can be little doubt that the lassitude and prostration often experienced during a Russian winter, notwithstanding the invigorating effect of out-door drives or walking exercise in sharp frosts, is attributable in no small degree to the excessive heat of the rooms and the insufficient ventilation. The only ventilator in use, a sort of Archimedean tin fan-wheel, in a case which is fitted into the window or flue. Among the appliances for heating, calorifers erected in the basement of large houses, with a system of flues, have to some extent been adopted in the capital, but it is a question whether they are sufficiently economical to be applied for general use. The Gurney stove has found some favor in some of the larger establishments of the city. Here there is a wide field open for our countrymen. An invention that would

combine economy of fuel with efficiency as to heating would be sure to meet with an enormous patronage all over the empire.

Like all large cities of Europe, the capital of Russia has introduced gas for lighting purposes. Three ineffectual attempts were made to light St. Petersburg with gas before the establishment of the present two companies. The first was during the reign of Alexander I., when, just as all arrangements were complete, the buildings caught fire, and the plan was abandoned for some years. The second attempt was made after the accession of the late Emperor Nicholas. The high and ungainly building intended for the gasholder was injudiciously placed near the Winter Palace, and formed so prominent a deformity that the Emperor was glad, in 1838, to buy up the whole of the premises belonging to the Company, for the purpose of pulling them down. The Company then went to work again, and in the autumn of 1839, when people were beginning to look forward to light streets in winter, the whole illumination was opened and closed on the same day by a frightful explosion, by which the gasholder was destroyed, a number of people were killed, and the money of the shareholders was lost. Shortly afterwards, gasworks were erected in the suburbs by an English firm, which was a complete success, and has continued so up to the present time. It is only recently that another company of the same kind has been formed; the work was also executed by an English firm. The coal is imported from England, and the price of gas per 1,000 about 10s. 6d. It must be admitted that the streets of St. Petersburg, whereever gas has been introduced, are better lighted than they are in London; the number of lamps is greater in a given distance; the burners and quality of the gas is better; the lamp-posts, also, better finished, and certainly ornamental, when compared with the regulation pattern of our metropolis. Gas does not find its way so readily inside the houses; it is confined entirely to the yards, staircases, etc., except in public establishments, shops, hotels, etc., where the fittings are always of the roughest description. Glass globes are never seen on the chandeliers. A short time ago an English company was formed in London—the Moscow Gas Company—who undertook the construction of works in that city. More than 40,000 lamps have already been erected. All the large factories and works in the neighborhood of St. Petersburg have their own gasworks, and they have been introduced in the interior establishments of the same kind, as well as on manorial estates. England supplies nearly all the work.

From lighting we naturally come to paving. The ever-increasing traffic in the capital of St. Petersburg, has called for improvements in paving. Until now almost the only paving-stone known is the common boulder. Many trials have been made to substitute for the old material, iron, asphaltum, granite blocks, macadam, resulting more or less in failures, owing to the action of the frost; as an exception, perhaps, may be taken the wood pavement, which consists of sexagon blocks laid on to 2 in. tarred planks, and secured together by wooden pins, tar being used as a cement. Over this the carriages roll as smoothly as on a tramway. This kind of pavement, however, has only been adopted in some of the principal streets, and necessitates constant repair, owing to the watery soil. The paving of the capital falls to the lot of the house proprietor, who is bound to provide the same opposite his house, and keep it in order. Even the common pavement is dear, notwithstanding the low cost of labor, and of the material, which is gathered in the vicinity, on the coast of Finland; it requires constant repair, owing to the marshy nature of the soil. The winter roads serve to mitigate the punishment inflicted on the traveller in the St. Petersburg streets. Nature has provided, by means of snow and ice, a more convenient road for man and horse than any that art has been able to construct; it is astonishing to compare the wear and tear of a sledge with a wheeled vehicle.

Latterly the introduction of tramways for the conveyance of passengers along the principal streets has proved a boon to the public of St. Petersburg, as well as a commercial success, and is likely to meet with considerable extension. The rails and some of the carriages were ordered from this country. Tramways have also been introduced for conveying goods from the quays to the custom-house.

Iron, as applied in this country for

various architectural purposes, such as girders, house-railings, large bridges, etc., is but very little used in the capital, and consequently in all other towns, as an exception, may be taken the railings of squares and gardens. At the Exhibition there was only one girder exhibited by a Government establishment. The northern side of the Summer Gardens of St. Petersburg is celebrated for its iron railings with its fanciful garlands and arabesques, which, people say, an Englishman once travelled all the way from London to see, and make a sketch of, and then returned, satisfied with his journey, not deigning to cast an eye upon any other monuments of the city. However, it is a very elaborate specimen of iron-founding, and scarcely to be equalled anywhere.

There is only one iron bridge over the Neva,—a very fine sample of modern engineering. Another iron bridge is wanted further up the river, and plans for the same have already been submitted to the authorities. The communication between the two banks of the river is kept up to a large extent by means of pontoon bridges, one of these being $\frac{3}{4}$ of a mile long.

In a sanitary point of view, St. Petersburg, and, in fact, all Russian towns are in a deplorable condition. Drainage is unknown in the capital, except in the immediate vicinity of the river, which is a serious matter for a town containing something like 700,000 inhabitants, and which is proved by the chronic prevalence of Asiatic cholera. The houses, as a rule, are veritable whitened sepulchres ; the effluvium from the latrines and dust-holes is horrible. The general and special smells of St. Petersburg in the spring and summer are hardly to be matched in any part of Europe. It is only within the last few weeks, on the outbreak of cholera, that stringent measures have beeen taken with a view to mitigate the evil to some extent by imposing fines upon the landlords. But all this is useless ; and until a proper system of drainage is introduced, matters are likely to remain much in the same condition.

Some few years ago waterworks were established. Until then all the water had to be carried in huge casks from the canals and river. It would appear, however, that comparatively few have availed themselves of the luxury of Neva water brought into the houses, the supply being confined chiefly to the streets, where several public fountains have been erected, from which the houses in the vicinity are supplied.

With the extension of the system of railways the towns of the interior are beginning to wake up also. Finding a necessity for a constant and uninterrupted supply of water, they have introduced waterworks, for instance, in the towns of Vladimir, Saratof, Kharkof, Nijni, and Novgorod. The construction of these establishments in Russia affords many facilities, on account of the numerous rivers, and at the same time great difficulties, owing to the action of the frost upon the pipes if not sunk sufficiently deep. The important town of Odessa is only now beginning to adopt the present system of water-supplying. Situated in a locality where there are neither springs nor rivers, it has until now depended entirely upon well, rain water, and a brackish water supplied from an aqueduct yielding about 300,000 gals. daily.

Among the innovations at St. Petersburg is the appearance of water-carts on the English principle. Appliances for gas-lighting and drainage were not shown at the St. Petersburg Exhibition of 1870.

From "Cosmos" we obtain the information that M. Böttger has produced a new test paper which is highly sensitive towards the alkalies and alkaline earths. The reagent is a magnificent coloring matter, obtained from the leaves of an exotic plant (*Coleus verschaffelti*), upon digestion for 24 hours with absolute alcohol, to which a few drops of sulphuric acid have been added. The paper is prepared for use by the usual process. The color is a splendid red, which passes more or less rapidly into a fine shade of green by the action of the alkalies or the alkaline earths. It is far more sensitive than turmeric; it is unaffected by carbonic acid, and will indicate the presence of the least traces of the carbonates of the alkaline earths in water. A moistened strip of the paper, when held at the opening of a gas jet, immediately assumes a green color if ammonia be present.

TELEGRAPHY—THE PNEUMATIC TUBE SYSTEM.

From "The Mechanics' Magazine."

The history of various attempts to promote means of pneumatic communication has been one of great variety. It is many years since a railway system was started on this plan in South Devon; this, and others, proved to be great failures; too much was attempted, and they were unsuccessful. Had the old experiments commenced from small beginnings, different results might have been achieved. In the present time we have witnessed the failure of the Waterloo and Whitehall line, projected to be worked by the pneumatic system, which, as is well known, came to nothing. Not that its want of success was due to any peculiar or inherent defects in the system itself, but rather to the financial fever that, about the same time, left the money-market in so depressed a state.

The Whitehall scheme was, however, the result of small beginnings, which had incontestably proved the value of a pneumatic system as a means of communication; firstly, by the extensive use the Electric Telegraph Company had made of it for the conveyance of messages for a short distance; and, secondly, by the success, in rapidity and transport, resulting from the adoption of a larger means of communication, for the carriage of mails and parcels by a large under-ground pipe, worked on the pneumatic plan, by means of which carriages running on wheels were easily transported for a considerable distance.

It is, however, with the system adopted by the Electric Company, for facilitating telegraphic purposes, that we now propose to deal, and to show how the system has been worked, how successfully it has been carried on, and to what an extent it has lately been expanded for the public telegraphic business.

Mr. Latimer Clark, Engineer to the Electric and International Telegraph Company, had greatly interested himself in pneumatic communications, and the system now in operation decidedly owes its parentage and success to him. He laid down for the Company a tube from their office in Founders' Court for the transmission of messages from the Stock Exchange. This tube was of lead, $1\frac{1}{2}$ in. in diameter, and perfectly smooth in the interior; the joints being carefully made for that end. This lead tube was laid within split iron pipes, great care being taken with regard to the curves. The engine and vacuum reservoir were fixed at Founders' Court, Lothbury, a vacuum being constantly maintained in the tube. The messages were tightly packed in a cylindrical carrier, having flanges so as to fit the tube; by means of a valve at the sending station the carrier was introduced into the tube, and by the influence of the vacuum in front, and the pressure of air behind, the carrier in a few seconds arrived at its destination. So successful was this application for the purpose of facilitating communication between a branch station and the head office, that it was soon extended to other offices where telegraphic correspondence was equally large.

This plan worked for some time with uninterrupted success, few stoppages ever having occurred. Subsequently, a change was made by Mr. C. F. Varley, who succeeded Mr. Clark as Engineer to the Company. It will be seen that under the original plan it was possible at the head office only to receive messages from the other office. Mr. Varley introduced an improvement, whereby an office could either transmit or receive.

This was effected by having at the head office a pressure, as well as a vacuum reservoir, and by making some alterations in the valve. By inserting a carrier in the tube at the head office, and exerting the pneumatic pressure, it was sent through the tube to the destined station. The head office, therefore, received its carriers from the out stations by means of a vacuum, and forwarded them by means of pressure. The tubes thus became doubly useful, and increased extension became the order of the day; the transfer of the Head Office to Telegraph street simply caused an extension of the tubes, and a transfer of the engine and apparatus.

The transfer of the telegraph to the Post Office introduced an increase in the

extension, and a reference to the accompanying list of tubes in London will show the increase due to the Post Office, marked thus † :—

Return showing the number of Pneumatic Tubes worked on Clarke's System in, London, and the time occupied in the Transmission of Messages.

From Engine Station.	To	Indicated Horse Power of Engine.	Length of Tube.	Diameter of Tube.	Time occupied in Transmission. Pressure.	Vacuum.
			yards.	ins.	min. sec.	min. sec.
Telegraph street......	Fenchurch street..........	40	980	2¼	1 5	1 20
"	Leadenall street...........	40	659	2¼	0 35	0 38
† "	Baltic Coffee House.......	40	590	2¼	0 35	0 38
"	Gresham House	40	588	1½	0 40	0 51
† "	Threadneedle street	40	566	2¼	0 34	0 48
† "	Threadneedle street	40	559	2¼	0 32	0 45
"	Cornhill..................	40	490	1½	0 37	0 40
"	Old Broad street	40	370	1½	0 25	0 29
† "	Lloyd's	40	343	1½	0 17	0 25
"	Stock Exchange..........	40	314	1½	0 15	0 15
"	Founders' Court..........	40	223	1½	0 13	0 14
"	Anglo-American Office.....	40	62	2¼	0 5	0 6
"	Indo-European Office......	40	57	2¼	0 5	0 5
"	Engineers' Office..........	40	50	2¼	0 4	0 5
"	South Gallery	40	50	2¼	....	....
"	Intelligence Department...	40	44	1½	0 5	0 6
† "	Metropolitan Gallery......	40	29	2¼	0 5	0 4
Total length—yards	....	....	5,974	....	....	....

On referring to the above list it will be seen that these extensions were to the eastward of the Head Office. The postal authorities, however deemed it expedient to make further extensions westward, and tubes have consequently been laid down from Telegraph street to St. Martin's le Grand (the General Post Office), Temple Bar, and Charing Cross. In this extension, in consequence of the success attending a plan of pneumatic communication introduced by Mr. Siemens, in Berlin, it was determined to use his system, especially as it effected great economy in the laying of the pipes.

Mr. Siemens' plan is different from that we have described, inasmuch as it effects communication with a number of stations in the same route, and acting as intermediate stations; whereas, under the usual system only 2 stations were united. But in Siemens' plan it is necessary either to have a tube following a circular route, and returning to the office whence it started, or to have a double tube. For direct communication to places in the same line, this system seems costly on account of the double tube; but, where the tubes have been laid down in Berlin, the communication makes a complete circuit, starting from and returning to one point, and supplying many intermediate stations.

Instead of the highly-surfaced lead pipe, Mr. Siemens uses a 3-in. iron pipe, carefully jointed; it is found, however, very difficult to obtain these pipes without roughness and excrescences in the interior, which soon damage the carrier.

A pumping-engine, with air-pump, is attached, and begins exhausting the air in the tube, which is open at the adjoining but remote end; it will be seen, therefore, that a carrier introduced at the open end will be propelled forward, and traverse the entire circle. In the original plan the carrier was made to travel from station to station, messages being taken out, and fresh ones being put in as required, at the various stations; a switch-box was provided moving on hinges, and presenting a circular opening through it, continuous with the tube, so that there was no interruption to the forward motion of the carrier; but on shifting the box, a receptacle with a cushioned end was presented, so that

the carrier and messages were arrested. The carrier being taken out, messages exchanged, and the carrier put into the through part of the switch-box, this was again returned to its normal position, when the carrier resumed its journey.

When the switch-box was moved so as to intercept the carrier, it will be evident that, without special provision, there would at once be a stop to the free circulation of the air, which is the specialty of this plan. To avoid this a bent tube was connected with the iron pipe on both sides of the switch-box, acting for the time as the main line of air circulation, whilst the box became as it were a blind siding.

In addition to the pneumatic tubes in London there are also numerous tubes in the provinces worked on the same system. The following statement shows their number and length :

Return Showing the Number of Pneumatic Tubes in Provincial Towns, and the time occupied in the Transmission of Messages, etc.

(The tubes marked * have been laid since the transfer.)

From.	From (Engine Station.)	To.	Indicated Horse Power of Engine.	Length of Tube.	Diameter of Tube.	Time occupied in Transmission. Pressure.	Vacuum.
				Yards.	ins.	min. sec.	min. sec.
Liverpool *	General Post Office..	Exchange	17	791	$2\frac{1}{4}$	0 45	0 $57\frac{1}{2}$
" *	" " ..	Water street	17	797	$1\frac{1}{2}$	1 5	....
" *	" " ..	County Galway	17	24	$1\frac{1}{2}$	0 4	....
Total length—yards.	....	....	....	1,612			
Manchester	York street	Ducrie Buildings	13	500	$1\frac{1}{2}$	0 29	0 30
"	"	Mocley street	13	300	$1\frac{1}{2}$	0 16	0 17
" *	"	Post Office	13	225	$1\frac{1}{2}$	0 $8\frac{1}{2}$	0 9
"	"	Counter	13	17	$1\frac{1}{2}$	0 2	0 2
Total length—yards.	....	....	....	1,042			
Birmingham	Exchange Buildings.	New street, Ry. Station	3	140	$1\frac{1}{2}$	0 $6\frac{1}{2}$	....
" *	" "	Cannon street	3	240	$1\frac{1}{2}$	0 11	....
" *	" "	Post Office	3	318	$1\frac{1}{2}$	0 24	....
Total length—yards.	....	....	....	698			
Glasgow	General Post Office..	Royal Exchange	7	242	$2\frac{1}{4}$	0 22	0 30
Total length—miles.	....	....	....	2 miles 74 yds.			

Between Telegraph street and the General Post Office, a distance of 852 yards, 2 tubes were laid side by side, making a length of 1,704 yards of piping. The communication was worked with the existing machinery, and found to answer very well ; and subsequently the tubes were extended to Temple Bar, a further distance of 1,333 yards, or 2,666 yards of piping, making the General Post Office an intermediate station.

In Mr. Scudamore's report on this subject, he remarks : "The double tube forms what may be called a pneumatic railway, with an up-line and a down-line, having their termini in Telegraph street

and at Temple Bar, and an intermediate station at the General Post Office. The up and down lines may be open throughout their entire length, or may be blocked by switch-boxes at the intermediate station. The terminal stations can send carriers through to each other without stopping at the intermediate station, or can send carriers to be stopped by the switch-box at the intermediate station, and the intermediate station when it knows a through carrier to be coming for one of the termini, can, if it happens to have any message of its own for that terminus, switch out the through carrier, insert its own messages, and send the carrier on again without any appreciable delay. The tube being of large size, the carriers are proportionately large, and each will hold about 50 messages.

"When pressure and vacuum are employed the distance between Telegraph street and Temple Bar is traversed in 3 min.; when vacuum only is employed 5 min. are required for the transmission.

"The tube is now working much within its power, and yet is doing work which fully occupied 6 wires and 12 clerks. If the extension to Charing Cross be successful, as there is every reason to suppose, the tube will take up with ease the work of 12 more clerks."

As there would be some difficulty in working the line under ordinary circumstances, it is arranged to work on the ordinary railway block system, with a special code for description of carriers. This plan has been found to answer very well; and the traffic is carried on without stoppage.

In Mr. Siemens' original system it was intended to work the tube, keeping up the circulation by means of a vacuum in front of the carrier, the rear of the tube being subject only to the ordinary pressure of the atmosphere. With the Post Office tube this transmission was found to be slow, and the experiment was tried of working by pressure as well as by vacuum, or the two combined; and the effect of this was to reduce the time from 5 to 3 min.

In addition to those stated in the foregoing table, three tubes have just been completed in Dublin, one of 1,530 yards and two of 700 yards each. So the total mileage of pneumatic tubes in the United Kingdom, will be—

London............	3	694	Clarke's System.
"	2	850	Siemens' "
Dublin	1	1,170	Clarke's "
Liverpool		1,612	
Manchester		1,042	
Birmingham		698	
Glasgow		242	
Total length........	9	1,028	

Referring to the information given as regards speed of transmission, it will be seen that a greater speed is obtained with the larger size pipe. Liverpool gives a striking example of this, for with 2 pipes of nearly the same length the time of transmission in the smaller pipe is nearly half as long again as in the larger pipe. It has been found in practice the best plan to use the $1\frac{1}{2}$-in. pipe for short distances, but for distances over 500 yards it is most advisable to use the $2\frac{1}{2}$-in. pipe. The speed of transmission through different lengths of pipe is found to vary inversely as the squares of the distances, *i. e.*, in straight pipe. In practice it is found experimentally that the various curves and inclines affect the speed materially, and therefore the law given does not work out correct in practice, but the actual result comes between the inverse proportion of the length and that of the squares of the length.

The tubes are very enduring, as repairs hardly appear to be required, and the number of extensions already made by the Post Office, and the fact that others are contemplated, is sufficient evidence of the estimation in which the pneumatic system is held, as regards its great utility and value.

A New Jersey decision makes railroad companies responsible for local improvements, paving, grading, etc., in cities, notwithstanding the usual stipulation of railroad charters that the tax of $\frac{1}{2}$ of 1 per cent. per annum paid into the State Treasury should be in lieu of all other assessments to be imposed upon them.

A movement is on foot for erecting a bridge over the river Blyth, and with full concurrence of the Blyth Harbor and Dock Committee.

TRANSMISSION OF POWER BY WIRE ROPES.*

If an account of the transmission of power by wire ropes would be of sufficient interest to your many friends and patrons, you are at liberty to appropriate the following general statement to the columns of your valuable journal, when not required for more interesting, or, perhaps, instructive matter.

Immediately preceding my recent hurried departure for the Continent, my attention was directed by my friend, Col. J. Albert Munroe, Civil Engineer, of Providence, R. I., to the economy in the development of water (and other) power by a system of its transmission, successfully in operation in Germany, but as yet believed to be without adoption, *if known*, in the United States. The subject was one of no ordinary interest to me, as Col. Munroe had been recently employed in making plans and estimates for the development of a very valuable but unimproved water power and estate, which I have for several years hoped to see occupied and fully developed by an association of capitalists having the pecuniary ability necessary for that purpose, and beyond my own. My friend's action was valuably assisted by Col. W. A. Roebling, Civil Engineer, of Brooklyn, N. Y., who not only informed him of the pamphlet publications upon this subject, but of the particular localities where the plan was in successful operation. One of these being at Hohemark, near these springs, I visited the place last Wednesday (June 28), and premising the statement of what I saw by stating that my observations were made in a heavy rain storm, and a long walk in mud and wet, which must account for any discrepancies of fact in measurements, the results obtained were these.

There is a very large cotton yarn manufactory, employing about 450 hands, that is driven by steam and water power combined, having 150-horse power from the former and 100 from the latter. The former is from a double-acting engine, having 1 cylinder of 3 ft. diameter and 5 ft. stroke, the other cylinder of 2 ft. diameter and 4 ft. stroke, driving a large 12 ft. gear, and making, as per register, in the 12 hours' labor the day previous, 84,035 revolutions. The valves of the large cylinder were about 5 in. opening, and operated by the ordinary eccentric on the crank shaft. I observed none of the more modern appliances of cut-offs, which might have arisen from a more critical knowledge being necessary on my part. The engine was made by Benj. Hick & Son, of Bolton, England, horizontal, and of excellent finish and operation. There were 3 tubular boilers, whose capacity I did not learn. Upon the ordinary crank shaft of the engine were bevelled wheels, receiving power from 2 Turbine wheels, of perhaps 3 ft. diameter.

Upon the outside of the wheel-house a large 12 or more feet iron wheel was revolving at the rate of 140 revolutions per minute, receiving its power from a similar wheel by means of a wire rope $\frac{3}{4}$ in. in diameter. There are 8 of these wheels, with 2 grooves in each (for receiving and transmitting power), 400 ft. apart, upon triangular iron frames, supported by strong stone under-structure and with 2 *spare* wire ropes for each 2 wheels, arranged for immediate application in case of injury to the 1 or 2 operating. The power thus transmitted is from a third Turbine, over 1,200 ft. from the mill, in a separate wheel-house, and connected also with the mill by telegraph wires, the wheel or gate tender living in an upper story of the small wheel-house, to receive or transmit information as necessary. The water supply to this third Turbine is brought from the Taunus Mountains, over a mile distant, in boiler iron tubes 18 in. in diameter. The tubes terminate at the mountain in a reservoir of cement 18 ft. square and 20 ft. in depth. The overflow of surplus water from the reservoir is conducted by means of an ordinary aqueduct to the 2 Turbines at the mill. One peculiarity in the application of the water to the Turbines arrested my attention. It *appeared* to be *horizontal* in direction, and not vertical, as I observed no cylinder in which the wheels were placed (it is true the submersion may have prevented their being seen), but the wheel-houses were square, and the water was thrown with great violence against the sides. The fall from the mountain reservoir to the mill is 400 ft. (through the iron tubes

* By Elisha Dyer, in a letter to "American Railway Times."

and aqueducts), and is explanatory of the force applied to the Turbines. The wire ropes are in coils of 250 metres in length (equal to very nearly 850 ft.), and cost from 140 to 150 florins per rope ($55 to $60) at the manufactory. The ordinary wear of a rope is from 6 to 8 weeks, except in imperfect manufacture or inferior material, where the liability of breakage is of course greater.

I think there can be but little question, from what I saw, of the expediency of a thorough examination of this subject in the United States. I am aware of the very great difference in cost of labor and material with us, from the continent of Europe. But taking into consideration the great expense of bulkheads to the canals or trenches from the dam, the still greater cost and difficulty of the excavation and construction of wheel pits and houses, I can but think there may be a less disparity in cost than would at first seem to exist. The superior advantages in selecting building sites, where material for building, security of foundation, and less of liability to damage by freshets, can be considered are very important arguments for the adoption of this mode of creating and transmitting power. The bulkhead and gates of an ordinary water power could as easily be constructed for the occupancy and use of the Turbine, or more ordinary breast and bucket wheels, as at present. The race-way might require additional length and depth to secure the advantages of the head and fall. But this part of the development of water power is generally of less cost than any other, requiring but little masonry or cement work after leaving the wheel pit. The different applications of this power, in different directions of different quantities, the avoiding of bevel gears, change of motion, and the numberless suggestions and advantages its adoption would produce, make it appear strange that, with all the scientific progress of our mechanic arts, and economical appliances in generating power by steam or water, for 20 years this principle has been so successfully applied in Germany, with full published particulars of construction and use, and yet, except in the most minor manner and detail, it is comparatively unknown to us.

Before leaving this imperfect account of Hohemark, I should add, as of interest to the different advocates of free duties and a protective tariff, that the children employed in the mill, from 14 to 16 years of age, receive 32 kreutzers per day of 12 hours' labor (equal to 22 cents); from 16 to 18, 34 kreutzers; adults, men, 1 florin, (60 kreutzers—40 cents); and the spinners, 1 florin, 12 kreutzers per day. The production of the mill is 4,000 to 5,000 lbs. of yarn daily. American and Indian cottons are used, but the former is decidedly preferred on account of superiority of strength and fineness of fibre. The association or company hold the property in shares, and its pecuniary results indicate energy, intelligence, and success. I may further add that the revolutions of the steam engine were distinctly and accurately indicated by a very simple indicator made by Schaeffer & Budenberg, Buckau-Magdeburg, No. 3,588. The register for June 23 (12½ hours' operation), 92,801; June 24 (12 hours), 80,348; 26th, 83,624; and 27th, 84,035.

Upon my table, open before me as I write, is the very interesting pamphlet and drawings of Prof. J. H. Kronauer upon the transmission of this same kind of power at the falls of the Rhine at Schaffhausen, and which is published by J. Winster & Co., Winterthur, 1870.

On the left bank of the river at Schaffhausen advantage has been taken of the rapids, and a dam being constructed across them somewhat of a triangular form, with the apex toward its downward flow, a Turbine wheel and house has been erected and placed. From this the power is transmitted to the right bank, up and across the river, as necessity or inclination required; down the river, and in fact it seemed as though fancy had merely to suggest a location, and, fairy like, a wheel was there revolving, as if by magic power, unseen. Corn mills, machine shops, turning shops, and any branch of industry requiring power, receives and transmits its incessant motion, *away* from the river, as if performing the most neighborly acts of kindness, ignorant of the source of its benefactions as well as of their value. Over 300 horse-power is now rented by the company developing it, and a large revenue is therefore remunerating them for their enterprise and energy. How much more can be rented I know not. But the force and quantity of the Rhine at Schaffhausen would seem as though

"the half had not been told." The origin of the enterprise, as the pamphlet states, was the energetic action of Heinrich Moser, of Charlottenfels, who formed the company, known in Germany as the Schaffhausen Water Works Association. The pamphlet of Professor Kronauer is full of details and plans so minute as to be a sufficient guide for the construction of similar works, comprehending even the tools employed.

Col. Munroe's second note also refers me to the efforts of the Swiss brothers, Hirn, in this same matter, the locality, however, not mentioned; also to a description of the same by Professor F. Realeaux, in his "Constructeur," but no date or place of its publication is given. At the Paris Exposition of 1867 this power was transmitted 300 ft. by means of a $\frac{1}{2}$-in. wire-rope. Fearing, Mr. Editor, my personal interest may have already trespassed upon your own and readers' patience, I retire from its further consideration, amply repaid if my efforts have your own and friends' commendation.

PLASTER OF PARIS MANUFACTURE.

From "Engineering."

The quarrying of gypsum and the manufacture of plaster are important industries in Paris, and we have recently taken the opportunity of visiting one of the establishments of this kind, the best arranged, that of M. Morel, at Montreuil. The plaster of paris, or gypsum, consists, as is well known, of hydrated sulphate of lime. The water being removed by roasting, the stone is ground into powder. When this is afterwards mixed with water, it combines itself again, and forms a solid mass, which is employed in an infinite variety of ways. The abundance of gypsum at Montmartre, Pantin, Menilmontant, Belleville, Charonne, Montreuil, etc., all close to Paris, even within the city limits ; the good quality of, and the large demand for the plaster, and the ease with which it is employed, have caused the development of this great industry in the capital. The plaster of paris has a European, and even a still more extended reputation. It is employed everywhere, and is put to the most varied uses. It is moulded into hollow bricks and tubular blocks, in building up partitions and walls, for paving slabs, and for smoke conduits to chimneys. One sees even in the neighborhood of the quarries, houses of 3 and 4 stories, which are built in moulded stones of plaster, or made in plaster in such a manner that they form a monolith.

The bed of gypsum worked at Pantin is horizontal; it has a thickness of 37 ft. 2 in. There is also a small bed adjacent, and of little thickness, but this is not quarried as a rule. The gypsum of this bed is almost entirely crystallized, and there are found there, in abundance, those beautiful specimens called *fers de lance*, on account of their form. These fragments split with ease into thin transparent leaves, and when the apparent limit of divisibility has been formed with the blade of a knife, if one takes one of the leaves, which has less than $\frac{1}{80}$ in. of thickness, and heats it, it exfoliates into more than 20 films, as the water it contains is heated and disengages itself in steam.

The bed of gypsum that is excavated is covered by some 40 ft. of earth, consisting of calcareous deposits and marl and clay. It is excavated, for the most part, by subterranean galleries, but it is sometimes found more economical to work from the surface, in spite of the great thickness of superincumbent earth, because there are numerous situations where the excavated material employed to fill elsewhere, can be made a source of revenue, while the limestone can be sold to make lime, and the clay to make earthenware or bricks.

It is thus that the quarry of Eprisette, worked at first in galleries by M. Morel, is changed at the present time into open excavation.

The gypsum is extracted by blasting. Holes are pierced in the rock, which, for the most part, is sufficiently soft for a workman to drive, in less than an hour, a hole from 4 ft. 6 in. to 6 ft. deep and 2 ft. in diameter. After a blast, the rock is struck with crowbars, which divides it into blocks from 30 to 40 metres cube, advantage being taken of the numerous faults in the material, which the workmen

learn to recognize at a glance, and which they call "*maillances.*" A heavy blow, or the introduction of a pick, at the right spot, divides easily the largest blocks into convenient fragments.

These fragments are loaded upon trolleys, which follow the face of the gallery or cutting on tramways, and which lead up to the 8 furnaces composing the factory. These kilns, or furnaces, are of the simplest form. They consist of an end wall 15 ft. long, and of 2 side walls of the same length. The 3 walls are also 15 ft. high, and the square hearth that they surround carries perpendicularly to the end wall 5 gratings, through which passes the air necessary for combustion. On the ground, the largest blocks of gypsum are arranged, in such a manner as to construct above these gratings arches sufficiently high to receive the fuel for burning the material. The spaces intervening are filled up with other fragments of rock, more of which is added from above, so that the height of the mass is raised. When the greatest height conveniently attainable by hand is reached, the charging of the kiln is continued from trolleys brought upon inclined planes, which are also supplied with rails. This is carried on until the height of the charge is equal to that of the walls of the kiln. All the interstices are then carefully packed with small fragments of the stone, and the front of the furnace, which is raised by a low wall, receives a movable cover of plate iron intended to prevent the loss of heat by radiation, and to retain such morsels of stone as become detached during the operation of baking; the joints in the front of the k ln are luted.

Everything being then prepared, fagots are placed within the arches and lighted, and when the embers are in full glow and the arches half empty, they are charged with briquettes of artificial fuel, and the fire is so managed by regulating the access of air, that the baking of the mass is effected equally throughout without any extremes of excessive or imperfect burning. The operation is complete in 24 hours.

The employment of briquettes is one of the improvements introduced by M. Morel into his establishment. The baking was generally done with wood, and the substitution of coal has effected a saving of $\frac{2}{3}$ of the total quantity produced. There is but a comparatively small loss of heat in this apparatus, so simple and apparently so primitive. In calculating the calorific power of the quantity of fuel consumed, and the amount of heat necessary to evaporate all the water contained in the gypsum, it is found that he utilizes $\frac{1}{2}$ of the available heat, which is certainly a satisfactory result, considering all the various losses inseparable from an identical enterprise.

After the calcination is complete, the furnace is allowed to cool, and the burnt gypsum is again loaded into wagons and carried off on the tramway to the grinding mills. This part of the manufacture consists of 2 parts. There are the mill stones in cast iron or stone, banded with rings of iron, and turning in a circular trough with a grated bottom. The calcined stone is fed into the mill, and those parts which are ground down extremely fine pass through its gratings. The rest is removed by a suitable mechanical appliance for grinding.

One of the mills carries a most ingenious arrangement for screening the fine powder. Below the grate there is a strainer in the form of a truncated cone. Of the powder which falls upon this strainer through the base of the annular grate, a part passes through the meshes and escapes through the lower part of the apparatus, the rest slides on the conical strainer falling on a table at the bottom, and is constantly lifted by a chain and replaced on the table of the mill. After the powder is sufficiently ground, it is conveyed below into a storehouse where it is placed in bags. The mills are driven by a 12-horse steam engine.

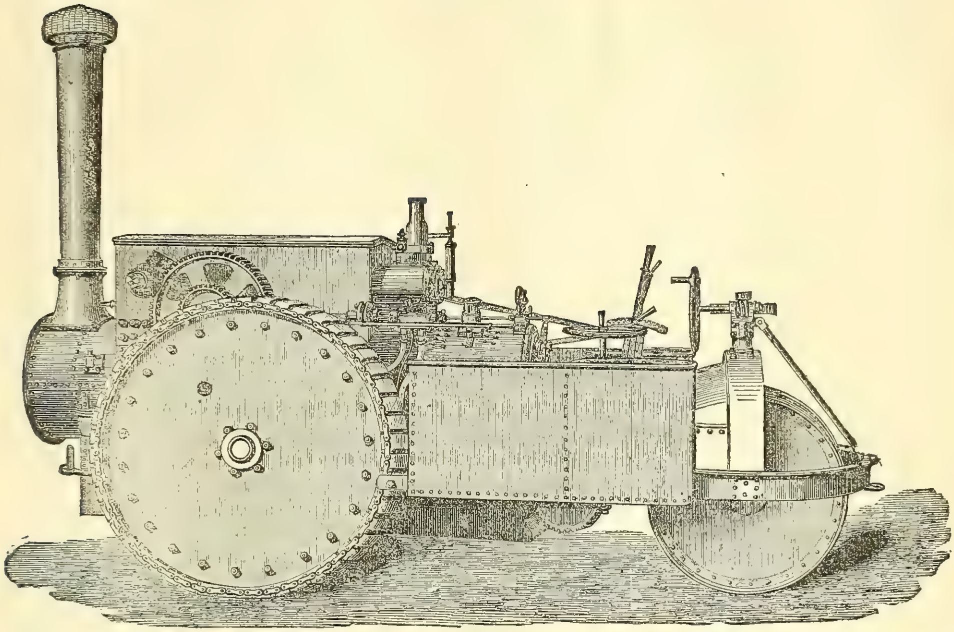
The whole of this establishment is ably arranged and managed, from the quarries to the plaster depot, and the working out of all the practical details does honor to the able proprietor who created them, and who still works daily to improve them.

EARL GRANVILLE believes there is no intention of continuing the Thames Embankment on the south side of the river.

SPECIMENS of coal and gold quartz, from the neighborhood of Bangalore, have been favorably reported on by Dr. Hunter.

STEAM ON COMMON ROADS.

From "The Engineer."



We give, in the above engraving, an illustration of that which is, in our opinion, one of the best designed locomotives yet constructed. The engine is nominally of 12-horse power, and has been made for the Turkish Government.

The engine is carried on 4 wheels, the 2 drivers being fitted with Thomson tires. They are 6 ft. $1\frac{1}{2}$ in. high, and the rubber tires are 14 in. wide. The steering wheels are of iron, with a raised central tire rib. They are 4 ft. 2 in. in diameter, and fixed on a short axle, so that they are very close together. A single vertical pin rises from the axle and is surrounded by a strong helical steel spring. The tires of these wheels are $7\frac{1}{4}$ in. wide.

The boiler is of the locomotive type, the fire-door being at the side, next the reader, and not shown in our illustration. The foot-plate is convenient and the coal space very large. The horizontal wheel shown actuates a worm wheel, which will be seen under the foot-plate. On the axis of the worm wheel is a pinion, which gears in a gun-metal rack or quadrant bolted to the boiler; by the use of this wheel the boiler can always be kept level on inclines. The device is not new, having been used by Mr. Smith, of Coven, many years ago, but it is very cleverly carried into practice. The fire-box has 26 sq. ft. of heating surface, and the tubes 205 ft.; total, 231 sq. ft. We need hardly add that the boiler produces an abundance of steam.

The cylinders are $7\frac{1}{4}$ ft. in diameter and 10 in. stroke. The crank shaft is of the best forged scrap iron, and all the bearings are of wrought iron, with long brasses. The eccentrics are turned out of the solid. The engine is double-geared on both sides, the wheels and pinions being all of McHaffie's malleable iron. The speeds are 4 and 8 miles per hour, and the total weight of the engine is 8 tons, of which the larger portion by far is carried on the drivers. The tank under the boiler holds about 250 gals.

The workmanship throughout is thoroughly good. Our illustration is taken from a photograph, and shows the engine unlagged and unpainted as it came into the yard fresh from the works, only having been finished a few hours before it was sent off by rail. It is to be regretted that it was not in time for the competition at Wolverhampton. It would certainly have taken a prominent place, and will doubtless give perfect satisfaction to its owners.

A Parliamentary paper recently issued consists of 3 copies of petitions received at the Board of Trade, with reference to the use of steam engines or locomotives on the common roads, and a memorandum on the subject by Captain Tyler. Two of the petitions from Ireland being identical in wording, we only reproduce one, a memorial by the magistrates, etc., of the county Kerry. The other petition emanates from the grand jury of the same county. The third comes from Leith. It may be as well to explain that some time since a private bill was passed for the construction of a tramroad on a public road in Kerry, and it was at first contem-

plated to work this road with horses ; it was subsequently very properly decided that it would be better to work it with small locomotives on traction engines, weighing about 7 tons, which, availing themselves of the tramway as much as possible, would yet be able to quit it for the ordinary road when need to do so came, so that the steam train could either get out of the way of ordinary vehicles, or take its wagons right up to the farmer's door. As to the recent progress of this scheme we are unable to speak ; but we have no doubt that the desire to use steam instead of horse power led to the preparation of the petitions in question. To whatever cause they are due, however, there can be no doubt that they express the wishes of a very large section of the community. Whether the old-fashioned people who still hold that the steam engine should find no place on our highways, wish it or not, the time has come when the traction engine must be recognized and admitted to a place with horses. The prejudice of the quadruped must give way to the interests of men. The horse must be educated to like the road steamer, or at all events to regard it with indifference; and far less difficulty will be incurred in imparting this education than is commonly supposed. Steam on our highways we must and shall have, and the sooner horses and their owners reconcile themselves to this fact the better for both.

Captain Tyler has taken a very sensible view of the matter, and most of his recommendations we cordially endorse. The rules which at present weigh most heavily on makers and users of traction engines are those which limit the speed to 2 miles an hour in towns and 4 miles an hour in the country, and further insist on the presence of a man with a red flag, at a distance of not less than 60 yards in front of the locomotive. The limitation of speed was introduced into the bill on the recommendation of a single eminent firm building traction engines, and was intended to get rid of certain nuisances in the shape of so called "pleasure" locomotives, for the most part hideous in design, noisy in action, and dangerous to their owners and every one else. These engines were run without caution at from 10 to 15 miles an hour, and they drew so much odium and contempt on the road steamer, and so strengthened the prejudice against it, that it was not improbable at one time that the use of traction engines in this country, then in their infancy, would be wholly prohibited. But this excuse for keeping down speed by legal enactment has completely passed away ; the legislation of the past 7 years or so has served its turn, and must give way to something better. We know that some makers of road locomotives still hold that 4 miles an hour is a sufficiently high speed under any circumstances, simply because they have hitherto confined themselves to the construction of engines which will go no faster ; their engines are admirable for hauling heavy loads, but the steam engine has a far wider field to fill than the hauling of heavy loads at 4 miles an hour. The conveyance of passengers should prove quite as remunerative under suitable conditions as the conveyance of goods. The Indian Government are already adopting steam trains on common roads ; in Egypt, in America, and on the Continent of Europe, the example of the Indian authorities is being followed, and our own country is not yet so fully supplied with the means of intercommunication that the steam omnibus should be considered as a thing unnecessary and to be legislated against. The Act restricting speed has done a great deal to retard the progress of mechanical science in the construction of road steamers, and in no way has it acted more prejudicially than in removing all temptation in the way of engineers to construct engines which shall be silent, sightly, and fast. It matters nothing, under existing circumstances, whether an engine is, or is not, a huge, ugly, lumbering piece of mechanism, simply because no responsibility worth the name attaches to the maker or user under the existing *régime;* so long as he has hired his red flag man, and his head light, and his slow speed, he can make as much noise with his engine, and the engine itself may be as fearful in its aspect, as he pleases. He may obstruct thoroughfares and frighten horses to his heart's content. But let Captain Tyler's recommendation be acted on, and let it once for all be decided that the user of an engine is to be responsible in the sense that any user of an ordinary vehicle is now responsible for damage done, and we shall find that much care will be taken to make traction engines inoffensive to

horses and men, and a stimulus will be at once imparted to engineers to produce machines much superior to any they have yet turned out of our workshops.

As regards the operation of the existing Act again, it is well known to all users of traction engines that it is practically *nil.* The man with the red flag never precedes the engine under ordinary circumstances; he carries his flag, and he gets carried himself on the engine or in one of the wagons, far more quickly and pleasantly than he can walk. He can always see a carriage or other vehicle far enough ahead to permit him to jump down and run his 60 yards ahead before it comes up to the engine. In towns the flag might be useful, if it were not superfluous. The noise made by the engine, and the rush of a crowd of dirty little boys, is always sufficient notice of the approach of a steam train through a town. The engine and the shouting can always be heard before the red flag can be seen. And besides, in 9 cases out of 10, if a horse manifests alarm, the man with the red flag rushes up to his head waving that objectionable bit of scarlet in his face in a way to startle any horse of average intellect. The engine he might get over, but the red flag and the engine combined we have always found too much for the strongest equine nerves, and in our own practice we have always insisted on the suppression of the flag the moment a timorous horse appeared on the road, and with the very happiest results. As regards speed, again, it does not appear to have struck our legislators that a traction engine moving at but 4 miles an hour, is certain to be passed from behind as often as it is passed from the front, and we have invariably found more trouble from vehicles coming up in the rear than from those approaching in front. Over and over again we have heard the words, "I do wish you would get on faster and keep out of people's way." To be consistent, the Legislature should have insisted on the presence of a man with a red flag behind the train as well as one in front. We have no hesitation in saying that the moment engines are permitted to proceed at 7 or 8 miles an hour, and do it, the chances of accident and the risk of obstruction to ordinary traffic will be reduced by one half.

The direction which legislation should take has been very properly laid down by Captain Tyler ; but we must take exception to his first proposition. It will be matter for regret if Parliament, acting on his recommendation, should insist on the adoption of the Le Chatellier brake, or, indeed, any other patented invention. It is perfectly well known to the drivers of traction engines that they can keep their engines in complete control with the ordinary reversing lever. If anything further is wanted it is supplied by the simple hoop brake, such as is used by Messrs. Aveling & Porter, of Rochester. The Chatellier brake would not provide for such a contingency as the fracture of a chain or the stripping of gear. All that it can do is done already, as we have said, by the ordinary link motion. On one point Captain Tyler is thoroughly right ; every traction engine should be worked under license from the Board of Trade. Under this restriction it would have been impossible for any one to have put on the road such an engine as that sent to Wolverhampton by a Shrewsbury firm. This engine ran away down a hill and killed the steersman almost on the spot. It will scarcely be credited, but it is no less true, that there were no brakes, and, in the proper sense of the word, no reversing gear. The engine must be stopped to shift the single eccentric round on the shaft. On its way to Wolverhampton this engine had to descend a hill ; steam was shut off, but it acquired an increasing velocity nevertheless. The driver, in his evidence before the coroner's jury, stated that he attempted to stop it with "a screw jack against the wheel ;" then the pitch chain—such a chain—came off, the engine turned into the ditch, and the poor steersman in front jumping off, or being knocked off, fell and was run over by the wagon following the engine. Under a proper system of examination and license such a casualty would not have occurred from such a cause.

We are pleased to find the manifestation in practice of a growing tendency on the part of engineers to make their engines more sightly and less likely to annoy horses than hitherto. Mr. Thomson and those working with him box up their gearing out of sight. Messrs. J. Fowler & Co. have adopted a capital remedy for the noise of the exhaust in the chimney, which is thoroughly efficient, and Messrs.

Burrell, of Thetford, have introduced a design in the shape of an engine intended for the Turkish Government (see illustration), which appears to us to be a decided step in the right direction. Some of the road steamers formerly built by Mr. Tuxford, have never been excelled in an æsthetic sense, whatever may have been their merits or demerits in other respects. With improved legislation, and the increased demand sure to follow for common road locomotives, it appears to be certain that improvements will be made in their construction which will speedily eliminate many of the causes of objection now brought against them.

ON STYLE IN ARCHITECTURE.

From "The Builder."

We offered, in a recent number, some remarks as to the meaning and value of what is called expression in architecture; one of those qualities which are more easily perceived than defined, but the importance of which is not to be on that account underrated. As we laid stress at the time on the existence of a marked distinction between *expression* and *style* in architecture, a few remarks as to the nature and distinctive characteristics of this latter quality can hardly be said to be *àpropos de rien.* As in the case of a good many terms in common use among us with regard to art, we have, in speaking of style, to clear away a certain amount of ambiguity of meaning before we can even arrive at a clear understanding as to what we are talking about. Style is a word very loosely used even in regard to architecture; still more so in its application in connection with other branches of art. We recognize, in a broad sense, various "styles" of the art of painting; but we speak also of the "style" of a particular artist in a much narrower sense, and with reference generally to distinctive peculiarities of manner. In speaking of literature, the word is used exclusively in this narrower sense, as indicating not the school of thought to which a writer belongs, but the distinctive characteristics of his mode of expression. The word as used in these two relations means in fact very much the same as we mean by "character" or "manner" in architecture. But in regard to the latter art we commonly use the word "style" in a wider sense, as the distinguishing name for differences between schools rather than between individual architects. We include under the general title of the "Gothic style," buildings in which the manner, or what we may term the handwriting, of the various designers is as distinct as possible. We formerly applied the term to all buildings with pointed arches; we have more recently perceived that what made Gothic a style lay deeper than that, and the meaning of the term has somewhat extended, to the length of becoming perhaps rather too vague. But inasmuch as we all recognize style as something distinct from expression, and are constantly making use of the word with more or less precision of meaning, we may contribute to a rather more definite idea on the subject by considering for a moment what "style" is,—what makes a style in architecture as distinct from mere character or expression.

There are necessary conditions for fulfilling the idea of style which are not very easily definable, though they are easily apprehended in a general way by the eye and mind, and would almost naturally occur to any one giving a thought to the subject,—we mean such things as the harmony and mutual fitness and suitability of the different decorative features in a building. We feel instinctively when this suitability does or does not exist. We should at once feel a sense of discord and unfitness in seeing such an ornament as the square Greek fret placed on a building in conjunction with or in proximity to a band of carved foliage in the Gothic style; but looking at the two features superficially, it is not so easy to point out wherein they are so discordant, what special qualities render their joint employment an anomaly. To arrive at this we must come to a broader generalization; we must look, not merely at the ornament, but at its relation to the whole structure and to the principles on which the latter is put together.

If we ascend from ornamental detail to larger portions of the structure, we feel equally the incongruity that would result, for instance, from placing a pointed Gothic arch between two bays and lintels from a Greek temple, or merely springing a Gothic arch, with the usual mouldings and chamfers, from a Classic column, although the column would carry it just as well, structurally, as would the orthodox clustered pier. It might be urged that the anomaly in this and the former case was merely the result of long association of ideas. Perhaps we need hardly say that we do not admit this. Our opinion is, that architectural style, properly so called, consists mainly in unity of construction and constructive expression carried out, not only in the main structural features, but imitated and repeated in a lesser degree by the smaller decorative features; which latter, however, in proportion as they recede from structure and become purely decorative, in that proportion escape more or less from this structural influence and come under the regulation of another artistic law which we shall refer to.

As to structural unity of principle as an element of style, that has been several times insisted on as a condition by architectural critics. So far as the main constructive portions of a building are concerned, the employment, in a building of any size or architectural importance, of *one* form of construction, trabeated, arcuated, domical, whatever it be, is not a new principle, in theory at least, and is practically illustrated in most of the great historical monuments of architecture. But the formation of a consistent architectural style requires also that the main motive of the construction be cartied out and exemplified in the detail of the building, a point which has not been so clearly recognized. This may be, indeed must be, done in two ways,—in regard to the main lines formed by the constructive portions of the building, and in regard also to the material used, and the method of treating it. In the Greek Doric style we see both requirement carried out nearly in perfection. Nearly the whole of the ornament (the sculpture is an accessory, not an architectural ornament) repeats, in its squareness, hardness, and rigidity of line, the square, heavy form of the pillar-and-beam construction. It is only when we get to the small finials or acroteria on the apse and spring of the pediment that we find any flowing lines, and those are arranged with a certain stiffness and precision to harmonize with the character of the whole building. Anything less rigidly conventionalized would be felt to be out of place at once. So, of course, with the Gothic, where every one knows how, in the full development of the style, the pointed arch is regularly carried out into even the smallest details; and even where the arch does not appear, the distinctive feature of the *point* is seldom lost sight of, and gives a crispness and sparkle to the smaller details closely allied to the treatment of the whole edifice. In the Saracenic style, again, the light form of the bulging and pointed dome gives, as it were, a license to the wild and elegant luxuriousness of ornament which characterizes the details of the style, where again not only is the appearance of lightness and pliability of material kept up in the details, but even the marked characteristic of the bulged dome, of the arch returned inward past its springing line, re-appears in the horse-shoe arches and sub-arches which abound in its fanciful arcades and wall-decorations. We are glancing here at the relation between detail and structure in regard to mere line and form; we must look at it, however, as hinted just now, in regard to treatment of material and relation of design and detail to the material. This establishes a relation between structure and detail in regard to some classes of detail, which, if we restricted our attention to mere outline, might seem to escape from this law. Such things, we mean, as sections of mouldings, plans of points of support, etc. What is it which really makes the incongruity in the case we supposed just now, of a Gothic arch springing from a Classic column? It is mainly the contrast between the deep, heavy mouldings and chamfers of the arch, and the shallow, delicate flutings of the column. We are here again brought round to constructive unity of design; for in every true and naturally developed style the mouldings and the surface treatment are the result of the consideration of the nature of the material. Greek architecture is essentially a marble style, Gothic architecture a stone style; a distinction which even now is scarcely appreciated,

but which, if it had been suspected 50 or 60 years ago, would have saved us a host of now meagre, desolate-looking, starved, would-be Greek erections, conceived and built in the vain idea of achieving in a comparatively dull, soft, and coarse material what could really only be effected in the bright, fine, hard marble in which the style originally rose into life. Deep sinkings, rounds, and hollows have no place in marble; they not only involve ruinous labor and expense, but lose the opportunity of showing the material in its most beautiful and perfect use, as capable of receiving and retaining the most delicate curves and contours, and the sharpest edges, and of preserving the effect of ornament more delicate than could be executed in any less hard and durable material. In dealing with stone, on the other hand the Mediæval architects felt that they had under their hands a coarse granular material, incapable (especially when exposed to the weather) of retaining a sharp arris or a delicate surface ornament; and they worked it accordingly into deep hollows, and took off by chamfering the edges which must soon have chamfered themselves. Marble and granite and such materials have no affinity with these expedients—a fact which is felt intuitively by modern masons; for who ever saw a polished granite pilaster with the arris chamfered off? We know better, even in the present day, than to despoil the material of the hard, sharp edge, which is one of its best characteristics. And viewing the relation between material and design in this light, do we not fairly establish the structural origin of style, even in regard to the sections of mouldings, when we look at these as taking their form and character from the nature and quality of the material, which in fact was the most important influence in determining the general structural design itself? We think so little of the nature of our material in these days; we are so apt to treat it at random in some preconceived manner, instead of in the manner best suited to "bring it to an excellent work," that we scarcely realize the intimate connection subsisting, in all unsophisticated and unforced architectural styles, between material and design. The recognition of this would go far to give something more like a consistent style to many of our modern buildings.

We alluded to another principle to which purely ornamental detail, in a consistent style, must bend, in proportion as it escapes from the dominion of structural considerations and structural form. There are generally to be found, in buildings of all styles, small details which seem so purely arbitrary and ornamental, that they may appear to have little or no dependence on the general style or structure of the building which they decorate. But even such details are bound by this law, that they cannot approach nearer to nature, cannot leave the conventional form of strictly architectural design, except in a ratio strictly consistent with the degree of conventionality subsisting in the general design. Small details may approach nearer to natural forms than can be suffered in the larger features of a building; but they must not be allowed to transgress disproportionately far in that direction. A Doric temple, for instance, is in a highly conventional style of architecture, and accordingly even the lightest and most unfettered of its details must be kept within the most artificial limits, and not suffered to approach in any way near to the irregularity of nature. Imagine the effect of a Gothic pinnacle, with its budding crockets and flowering finial, on the apex of a Greek pediment, and our meaning here will be obvious. Such an object, in such a situation, would appear simply ragged. But the Gothic and Saracenic, and some other styles, approach much nearer, in their general treatment and outline, to the picturesque forms of nature, and accordingly these styles will admit of ornamental detail which in proportion approaches still nearer to, and even very closely imitates, the form of natural vegetation. And this is the true æsthetic reason for the incongruity of appearance which would be presented by the supposed juxtaposition of the Greek fret and Gothic foliated carving, alluded to at the commencement of our remarks. Independently of their variety of form and character, they would not accord with each other because they are, if we may so speak, on different planes of departure from natural form; the Greek being very far, indeed almost entirely, removed therefrom, while the Gothic approaches much closer to it. So we see in all genuine architectural styles, that the *principles* only of nature being followed in the main

design, the *facts* of nature are allowed to be approached by regular gradation as we descend from the whole to the parts, and the more so as we go from details, which are partly constructional, or closely bound up with construction, to those which are purely ornamental; provided always that even in these latter an approach to natural fact is only warranted in proportion to the nearness to or distance from nature of the main design; that when the latter is purely architectonic and conventional, only a distant approach to nature can be permitted even in small details, and that this must be in regular gradation; *i. e.*, we cannot permit any one class of detail to assume an undue approach to natural form, out of proportion to what is allowed in other details in the same style, unless it be openly avowed as an addition to, and not a part of, the architecture (as in high-class sculpture applied to architecture). With this reservation, everything which approaches disproportionately near to natural form is an excrescence and an impertinence, and will not be found in connection with any true and consistent style.

Comparing theory, then, with the facts presented to us in the monuments of what we all agree to consider as among the most perfect architectural styles of the world, we are led to the conclusion that architectural consistency of design, which we call *style*, depends in the first place on structural consistency, in the employment throughout a building of one main principle of construction applied equally to the main structure and to the smaller structural details; secondly, on the carrying out and repetition of the main lines and structural treatment of material in all the smaller parts of the building in which structure is not entirely lost in decoration; and thirdly, in the principle, which controls every portion down to the smallest decorative feature, of consistency of treatment in regard to imitation of nature, which provides that the same building shall not present to us features strictly conventional combined with others which approach nearly to the irregularity of natural form, except just in that fit and proportionate gradation from the architectonic to the natural which is allowable, and even desirable, as we descend from the structural whole to the decorative portions. And here, then, it is evident wherein *expression*, which we treated of a few weeks back, differs from *style*. The latter is concerned with the treatment and relation of the architectural features, which form the integral part of our design ; expression is concerned with the proportion, the variety, the position in which we use these materials. They may be, in other words, a dozen buildings in the same style, all with equal purity of detail, and in which all the main facts of the detail are the same, but they may be arranged and grouped in so many different ways as to produce buildings with a dozen perfectly distinct expressions. That we should be led to such a conclusion from a logical process of examination, is a result which may be consoling to those who think we can have no originality of architectural design without the invention of what they term a "new style." Any style worth the name is capable, in competent hands, of almost infinite varieties of expression, if our definition of " expression " in our impression of May 6th be the correct one. There may be, we may add, buildings with a great deal of expression and character, though without purity of style; and purity and consistency of style and detail may occasionally be found almost entirely devoid of expression, except that kind of set expression of dead immobility which belongs to Egyptian sculpture. But the position of the two qualities is broadly this: Style deals with the principles on which we are to invent and combine our materials for architectural design ; expression is the result obtained by the varied manner, proportion, and juxtaposition in which such materials are used in special cases and by special minds.

In all probability we shall not see a single national style invented and universally adopted, in this or any other civilized country, as the Pointed style was in the middle ages. Modern education has given such variety and extent to our sympathies, that it is scarcely possible that the whole nation and the whole architectural profession could be again found to tread, by one consent, in the same steps, architecturally. Progress in this direction points rather to the adoption and maturing of 2 and 3 or more separate types of style, each with its own varieties of expression. Such types will, we believe, only be consistent and satisfactory if they adhere to the principles which

have governed former true and consistent architectural styles, and which have been, we believe, in the main, as hinted at above. Not that we have the slightest idea of the possibility of any architect or body of architects theorizing a new style into existence, out of the depths of their internal consciousness, on these or any other principles. Architectural styles never have been, and never will be, made cut and dried in that way. But it does not by any means follow, we submit, that, therefore, the subject is not one of interest in itself, and worthy of thought and consideration, which may prove suggestive in one way or another.

PRACTICAL ELECTRICITY.

From "Engineering."

M. Ernest Saint-Edme, Examiner in Physics at the Conservatoire des Arts et Métiers, and Professor of Physical Sciences, has just published an interesting volume on the application of electricity to the mechanical arts, in the navy, and in the theatres. Naturally he studies the sources of electricity, the apparatus employed, and all the various practical applications.

Amongst the sources of electricity, those most employed are galvanic elements; there exist of these a great variety, and it is difficult to say in which the inventor's ability has been most exercised. They are divided into 2 classes: those of great intensity and short duration; those of small intensity and of long duration. Among the first we may mention the bichromate of potassium element. In one series of vessels containing a solution of the bichromate, and $\frac{1}{100}$ part of anhydrous sulphuric acid, there is placed the necessary pair of plates, each formed of a plate of zinc, and 2 plates of charcoal; these are lifted out of the acid when the current is not required. This element, which produces a current of great intensity, is especially used in the service of exploding mines, or in surgical operations. In constant current batteries, the efforts of investigators direct themselves towards the suppression of porous vessels, the resistance of which, considerable when they are put in action, is much increased by the action of saline and metallic crystals.

In the element of M. Callaud, sulphate of copper and acidulated water are placed in the same vessel, and superimpose themselves in the order of their density. This battery cannot be moved about, but once installed in a fixed position, it gives a current of a very constant intensity. M. Minotti places in the same jar a disc of copper, then a layer of sulphate of copper in powder, then a bed of pure sand, supporting the zinc plate. When water is placed in the jar, the action of the element begins, and its intensity remains constant so long as the loss of water through evaporation is replaced.

The sulphate of mercury battery of M. Marié-Davy, used in the telegraph service during several years, has been abandoned, and a return has been made to the sulphate of copper battery, in non-porous jars. M. Grenet has for some time applied successfully to bell-ringing apparatus a sulphate of mercury battery with a non-porous vase.

In the Léclanché battery, the carbon is surrounded with a mixture of peroxide of magnesia and of graphite, and which contains a solution of chlorhydrate of ammonia. Although the official telegraph administration has not adopted this apparatus, it has, nevertheless, come into favor in a large number of applications.

M. Warren de la Rue employs couples formed of a zinc plate, and of chloride of silver, contained in flasks of hard rubber, filled with saline water, and hermetically sealed.

M. Gaiffe has applied a new battery to his electro-medical apparatus. Two couples are sufficient to obtain, during 24 hours, 50 times the force of one nitric acid element.

Electro-magnetic machinery has received extraordinary improvements since the first arrangements of Clarke or of Pixii. We may mention the Gaiffe machine, the Henley magneto-electric key, the Siemens magnetic coil, and the electro magnetic machines of M. Noillet, employed in France under the name of the Alliance machine, which is especially

applied in the production of the electric light.

The thermo-electric piles, which have remained much the same since 1821, do not enter into the industrial domains. M. Becquerel forms each element from a plate of sulphuret of copper and a plate of German silver, composed of copper, of zinc, and of nickel. The pile is heated by a gas jet. Thirty such elements suffice to decompose water, to heat a platinum wire to redness, and to excite an electro-magnet. Each element is equal to about a quarter of a Daniel's element. MM. Morre and Clamont replace the sulphuret of copper by sulphuret of lead, whose electromotive force is greater, and gives to the battery a more favorable power for utilizing the heat. All the inventions, however, of this class seem to represent but little progress in the delicate question of transforming heat into electricity.

The dynamic condenser of M. Garton Planté is a curious and important invention. It permits, so to speak, of an accumulation of the powers of a battery of 2 or 3 elements, until a discharge equal to the force of 50 or 60 is obtained. In a jar made with lateral grooves are arranged vertically a series of parallel lead plates, very close to each other, and perfectly insulated. One series of pairs of plates are connected, and put into connection with one of the poles furnishing the current. The same is done with the other series. The jar is filled with acidulated water. The current of the battery decomposes the water gradually, accumulating hydrogen on one group of plates, and oxygen on the other. If the two groups of plates are put into communication, the oxygen and hydrogen combine afresh, and produce a current of great intensity. The action of the apparatus may thus be indefinitely maintained. This condenser is employed almost exclusively in surgery.

Many applications have been made of electricity as a motive power: it is employed for driving sewing machines, in spinning factories, in railway brakes, etc., but it is especially in the transmission of indications that this power finds its most useful application. It is employed to send from a distance the thermometrical and barometrical observations, to indicate the presence of gas or fire-damp in mines; in some German towns, and also at Menton, near Nice, it is used to avoid premature inhumation.

After a rapid review of overland, underground, and submarine telegraphs, M. Saint-Edme takes up the consideration of the practical application of electricity to the marine. The protection of ships' plates and armor has been made the subject of special study by M. Becquerel at the port of Toulon. He has determined the electro-motive force of the metals and thin alloys entering into the construction of ships' plates, as compared with that of zinc, and has learnt what extent of surface of iron or copper a plate of zinc of given dimensions can protect.

Of electric lamps, those of Foucault and of Serrin supplied by an electro-magnetic apparatus, are employed for night signals on board ship, and for illuminating light-houses. During the last war the principal French iron-clads and gunboats were furnished with electric lanterns. By the help of this light, entry into port by night was possible, as well as manœuvres in the dark amongst crowded shipping. The same lamps can also be employed under water for submarine exploration.

Torpedoes have, of course, become a most important element of coast and harbor defence. To explode them the induction coil, with the Brequet exploder, is often employed, in which a current is generated by removing suddenly from the magnet its soft iron armature. The explosion is produced by the help of the Ebner fuses, in which the spark strikes a mixture of chlorate of potassium, of sulphuret of antimony, and of charcoal, or by Abel fuses. By this apparatus explosions can be produced at distances of 200 or 300 miles.

In the theatres for several years electricity has been employed for the transmission of signals, to give the time to musicians placed out of sight of the musical conductor, and by the help of the apparatus of M. Duboscq, to light up any given part of the stage. M. Saint-Edme gives some interesting details of this latter application. He describes the means for obtaining rainbows, lightning, and illuminated fountains. He describes, also, the employment of magnesium and other lights, and the production of spectral and phosphorescent phenomena.

Electricity gives very beautiful phosphoric effects well known in physics by the Geissler tubes. These are utilized in the theatres in a variety of forms; for example, they are employed in the illumination of diadems and other insignia, in transformation scenes, and in the imitation of fireworks. Thus each day the practical appplication of electricity is extending, and for further information we refer our readers to the book of M. Saint-Edme, from which we have compiled the foregoing facts, in preference to making a formal review of the work.

RANSOME'S STONE FOR CAISSONS.

From "The Builder."

The uses to which the silicious concrete stone, invented by Mr. Frederick Ransome, is applied, are already numerous and varied, but the limits of its capabilities have not yet been reached, it would appear.

In some mining districts, engine pits that are to be lined with ashlar are sunk by "travelling cribs." The crib consists of a strong cylinder of iron, chamfered on its under edge to the outside; the upper edge square, and broad enough, either in solid thickness or by flange, to give a full bed to the first course of ashlar, upon which others are superimposed, and the travelling crib sunk until the requisite depth is reached. The process by which the stone caissons will accomplish the same result is similar in some respects, but essentially different in others. The first section of the caisson, for instance, is shod with iron, and takes the duty of the travelling crib; for the rest there are no "courses" of ashlar, but a succession of cylinders, lowered one after another as the pioneer section descends, the joints tongued and easily made water-tight before the water-level is reached, in the case of all that follow those that have to be lowered, in the first instance, under the water-line.

It will be readily apparent that these caissons, provided that the material is of sufficient strength, are applicable to the construction of hydraulic works of various kinds. The cylinders having been lowered to the requisite depth, the process of filling with Portland cement concrete is sufficiently simple; and, inasmuch as the caissons may be lowered in any number, and according to any arrangement in relation to each other, piers, abutments, sea or embankment walls, of any required strength, may be constructed.

The application of Mr. Ransome's process to hydraulic construction has been suggested by Mr. J. W. Butler, of Willesden, by whom, in conjunction with Mr. Ransome, the stone caissons have been patented. One principal object of the patent is to provide a cheap and efficient substitute for stone for hydraulic works, and another to obviate the necessity for false works, coffer-dams and the like, and to secure a much less costly mode of construction than by iron cylinders and caissons.

The strength and quality of the material to be employed in the construction of these stone caissons is, of course, a consideration of essential importance. As regards its quality and power to resist certain influences, an important report has been made by Prof. Frankland, who has tested its comparative porosity, the action upon it by acid, and by boiling. The water absorbed by dry specimens he found as follows:—Bath stone, 1.57 per cent.; Caen, 9.86; Portland, 8.86; Ransome's patent, 6.53. Alteration in weight by immersion in 1 per cent. of acid: Bath, 1.28; Caen, 2.13; Portland, 1.60; Ransome's Patent, none. Loss by three applications of acid, and by boiling afterwards: Bath, 5.91; Caen, 11.73; Portland, 3.94; Ransome's, 0.63. Ransome's stone has also been subjected to the crucial test of being boiled and immediately transferred upon ice, without the slightest effect being produced. But its power to resist crushing weight is of greater importance than these tests. From a series of comparative experiments, it has been ascertained that granite has a power of resistance to crushing of from 8,000 lbs. to 12,000 lbs. per sq. in.; Portland stone, 2,630 lbs.; Bramley Fall, 5,120 lbs.; and Ransome's, 8,960 lbs.

MILITARY RAILWAY AND BRIDGE BUILDING.

From "The Chicago Railway Review."

The United States Military Railway organization was created by the necessities of the war for the Union. The territory over which our large armies operated was so extensive that they could only be fully supplied with the necessary subsistence for men and animals, and the material for war, by rail; and the field of operations was so continually changing, and the requirements of the service so varied, that it became necessary to have a complete organization prepared to move instantly wherever their services were wanted, and fully equipped and prepared to perform any kind of railway service from the building of a railway to operating it to its full capacity.

The first attempt made was to use soldiers for the Railway Corps, but this proved a failure. It was found that men could not be both good soldiers and mechanics; they either neglected one duty or the other; for no man could properly take care of and use both his arms and his tools. So the plan of employing soldiers in this service was abandoned, and in their stead a corps of civilians was organized, whose members were increased or diminished from time to time, as the exigencies of the service demanded. These men, of course, had some arms, and when occasion arose used them; but their main duty was railroading. This at times was attended with as great risk as any branch of the service; and many brave fellows sacrificed their lives for the cause as gallantly as any soldier who perished on the field of battle.

THE PERFECTED PLAN.

It was not until about Jan. 1, 1864, that all the military railways were placed under one head—Col. D. C. McCallum, who was stationed at Washington. About this time Gen. Sherman was put in command of the Military Division of the Mississippi, and the plans for his great Atlantic campaign, and his march to the sea, were being matured. The question of supplying his armies while conducting the Atlantic campaign was the great problem to be solved. Could the system of railways necessary for this purpose be opened up as rapidly as required, and maintained in running order? This new and untried problem was placed in the hands of Col. W. W. Wright to solve, who was appointed Chief Engineer of the military railways in the Military Division of the Mississippi—the territory under Gen. Sherman's command. How well he performed the part assigned him is best told in Gen. Sherman's report of the Atlantic campaign:

"I must bear full and liberal testimony to the energetic and successful management of our railways during the campaign. No matter when or where a break has been made, the repair train seemed on the spot, and the damage was repaired generally before I knew of the break. Bridges have been built with surprising rapidity, and the locomotive whistle was heard in our advanced camps almost before the echoes of the skirmish fire had ceased. Some of these bridges, the Oostanaula, the Etowah, and Chattahoochie, are firm, substantial structures, and were built in inconceivably short time, and almost out of material improvised on the spot.

"Col. W. W. Wright, who has charge of the construction and repairs, is not only a most skilful, but a wonderfully ingenious, industrious and zealous officer, and I can hardly do him justice."

Col. Wright's force of mechanics and laborers was called the "Construction Corps," and was organized into divisions of about 800 men each, composed of subdivisions and squads of men for every kind of railway work that might present. The number of these divisions was increased or diminished as the movements of the armies were extended or contracted—the average number being seven. Each division was constituted as follows:

	No. of Men.
Division Engineer	1
Assistant Engineer	1
Rodman	1
Clerk	1
Messengers	3
Total	6

Subdivision No. 1.

Supervisor of bridges and carpenter work	1
Clerk and Time-keeper	1
Commissary	1
Quartermaster	1
Surgeon	1
Hospital Steward	1
Foremen (one for each 50 men)	6
Sub-Foremen (one for each 10 men)	30

Mechanics and Laborers	300
Blacksmith and helper	2
Cooks	12
Total	356
Subdivision No. 2.	
Supervisor of track	1
Clerk and Time-keeper	1
Commissary	1
Quartermaster	1
Surgeon	1
Hospital Steward	1
Foremen	6
Sub-Foremen	30
Mechanics and Laborers	300
Blacksmith and helper	2
Cooks	12
Total	356
Subdivision No. 3.	
Supervisor of water stations	1
Foreman	1
Mechanics and Laborers	12
Cook	1
Total	15
Subdivision No. 4.	
Supervisor of masonry	1
Foreman	1
Masons and helpers	10
Cook	1
Total	13
Subdivision No. 5.	
Foreman of "Ox Brigade"	1
Ox drivers	18
Cook	1
Total	20
Train Crew.	
Conductors	2
Brakemen	4
Enginemen	2
Firemen	2
Cook	1
Total	11
Grand Total	777

Track laying and bridge building being the principal work, subdivisions Nos. 1 and 2 comprised the main part of each division. When it was necessary the whole division was employed at any piece of work. This extended field of operations, and the rapid movements of the corps, made the transportation of wagons and mules for their use impossible, so the necessary hauling was mainly done by oxen taken from the droves of beef cattle accompanying the armies. When necessary these could be killed for food. The work of the Construction Corps was a "new departure" in railway construction, and it inaugurated the rapid work which has been so successfully accomplished on our Pacific railways. Many feats of this corps might be cited, but two will suffice for the present.

The bridge over the Chattahoochie River on the line of the Chattanooga & Atlanta R., 12 miles from Atlanta, was built and ready for the passage of trains in $4\frac{1}{2}$ days. This structure was 780 ft. long and 90 ft. high. Nearly all the timber used in its construction was cut in the adjacent woods, and prepared within the time named, and the wreck of the old bridge (which had been burned), consisting of an immense mass of tangled wood and iron, had to be removed before the new one could be erected.

In October, 1864, Gen. Hood swung his army around to the rear of Sherman, who was at Atlanta, and destroyed 35 miles of the road leading to Chattanooga. The road was broken at several points, but there was one stretch of 25 miles in length where the track, bridges, water stations, and everything pertaining to the road was completely destroyed. This gap was rebuilt in $7\frac{1}{2}$ days. All the bridge timbers and nearly all the cross-ties had to be cut, and most of the latter were carried by men to the road, as there were not sufficient teams for hauling. Most of the iron rails were brought from Nashville, over 200 miles distant, and the balance were obtained from roads in the hands of the enemy, where a force had to be sent out every day to fight for what was wanted.

The high price of railway iron in 1864, and the difficulty of obtaining the required amount for military roads as far south as Chattanooga, induced the building of a rolling mill at that point for the purpose of working up the large amount of damaged rails that had accumulated on the different roads which the enemy had broken from time to time. This mill was built by the Construction Corps, at a cost of $290,000, and more than paid for itself in the rails manufactured for Government use, and after the close of the war was sold for $175,000.

TABULAR STATEMENT OF OPERATIONS.

The following table presents in a condensed form the amount and cost of work done by the Construction Corps on the roads named. Nearly the whole of this work was done in 1864, and its performance was substantially a part of the Atlanta campaign.

At the close of the war the Government turned over all the military railways to their former owners :

Cost of Materials used and Labor performed for Construction and Maintenance of Way on the U. S. Military Railways in the Military Division of the Mississippi.

NAME OF ROAD.	From	To	Length. Miles.	Bridges built by Govern't. ft. line'l.	TRACK. Miles laid by Government. Main tr'k.	Sidings.	Total.	COST. Materials.	Labor.	Cont't Work.	Total.
Nashville and Chattanooga	Nashville	Chattanooga	151	21,727	129 75-100	19	148 75-100	$1,747,741 00	$1,946,553 62	$385,216 71	$4,079,511 33
Shelbyville Branch	Wartrace	Shelbyville	9								
McMinnville and Manchester	Tullahoma	McMinnville	35								
Nashville and Decatur	Nashville	Decatur Junction	120	24,275	31 50-100	2 65-100	34 15-100	416,480 00	692,835 91	549,326 13	1,658,642 04
Mt. Pleasant Branch	Columbia	Mt. Pleasant	12								
Memphis and Charleston	Stevenson	Decatur Junction	80	4,943	3 50-100	1 07-100	4 57-100	75,685 00	206,308 18	88,442 33	380,435 51
Chattanooga and Knoxville	Chattanooga	Knoxville	112	4,002	35	3 38-100	38 38-100	542,030 50	506,554 45	161,990 26	1,210,575 21
Cleveland and Dalton Branch	Cleveland	Dalton	27								
Nashville and Northwestern	Nashville	Johnsonville	78	21,320	46 50-100	4 25-100	50 75-100	489,779 12	798,829 73	182,789 11	1,471,397 96
Chattanooga and Atlanta	Chattanooga	Atlanta	136	13,676	130 75-100	10 75-100	141 50-100	1,377,145 00	1,150,746 06	41,427 63	2,569,318 69
Rome Branch	Kingston	Rome	17								
Atlanta and Macon	Atlanta	Rough and Ready	11								
Nashville and Clarksville	Nashville	Clarksville	62	3,433	1 62-100	13	1 75-100	18,210 00	148,455 92		166,665 92
Knoxville and Bristol	Knoxville	Bristol	110	4,168	12 50-100	1 09-100	13 59-100	156,580 00	195,321 24		351,901 24
Rogersville Branch	Junction	Rogersville	12								
Memphis and Charleston	Memphis	Pocohontas	75					134,194 00	72,893 12		207,087 89
Mississippi Central	Grand Junction	Tallahatchie	48								
Mobile and Ohio	Columbus, Kent'y	Crockett, Tenn.	35					3,762 00	16,582 88		20,345 32
Louisville City	River Landing	L. & N. R. Depot	2								
Totals			1,132	*97,544	391 12-100	42 32-100	433 44-100	$4,961,607 83	$5,745,081 11	$1,409,192 17	$12,115,881 11

* 18 47-100 miles.

IRON AND STEEL NOTES.

Scotch Iron Manufacture.—Prof. Thurston, U.S., has lately been criticising rather sharply the Scotch practice of reducing iron ore. The great wastefulness of fuel, and the small amount of iron produced as compared with other districts, form the groundwork of his remarks. He states the number of furnaces in blast to be 127, and the production of the larger furnaces rarely exceeds 200 tons weekly, though the principal ore is the Scotch blackband, which contains 60 per cent. of iron after calcining. The roasting is often effected without much expense for fuel, the carbon contained in the ore being sufficient—4 to 10 per cent. is the usual quantity added. The calcined ore is charged into the furnace with from 20 to 30 per cent. of limestone, making about 2 tons of these materials per ton of iron. The proportion of fuel used there is, however, extravagant, averaging, as it does, between 45 cwt. and 50 cwt. per ton of iron, and to this has to be added the amount of slack required for steam and heating the blast. But his extremest surprise is raised at finding that the countrymen of Neilson either do not appreciate the full value of his discovery, or are unable to avail themselves of it, the heat from the blast rarely exceeding 700 deg., and its pressure upon the average furnace being about 3 lbs. to the sq. in. The extreme cheapness of fuel may have had its influence in producing the marked difference between the Scotch and Cleveland practice, but it is high time that the increasing expense of Scotch ores and the competition of other districts should cure anything like slovenliness in a manufacture of so much national importance. The product of the Scotch furnaces is usually of the well-known dark foundry grades, the phosphorus it contains giving it fluidity and easy fusibility. The lighter grades by careful puddling are made into fair wrought iron, as the Clyde yards can testify. The immense and rapid growth of the manufacture of steel by the pneumatic process has caused a corresponding demand for ores of exceptional purity, as it is impossible to work this process if the phosphorus attains 1 per cent.; hence it is that the Cumberland iron is so much in demand as to be beyond the producing power of the furnaces. Those ores are almost the ones turning out iron pure enough for the process. If all other districts devote their best skill to the treatment of the ores they have to do with, even phosphorus may be, perhaps, eliminated, now that it is known to be so detrimental.—*Mining Journal.*

Phosphorus in Iron and Steel.—A method of determining the amount of phosphorus in iron and steel is thus stated by Prof. C. A. Joy, in the "Journal of Applied Chemistry":

In the proceedings of the Chemical Society of Berlin, we find a method of analysis of iron proposed by F. Kessler, which appears to be easy of execution, and to afford accurate results. The process is briefly as follows: 5.6 grains of the substance are digested with nitric acid, evaporated to dryness, strongly ignited, dissolved in hydrochloric acid, reduced with sulphuretted hydrogen gas, treated with a solution of 42 grms. of ferrocyanide of potassium, the whole diluted to 518 cubic centimetres instead of 500, allowing 18 c. c. for the volume of the precipitate; 250 cubic centimetres of the filtrate from the above are measured off, and sulphate of magnesia and aqua am-

monia added to precipitate the phosphorus, which is afterwards determined as pyro-phosphate of magnesia in the usual way; 1 decigram of the magnesium phosphate indicates 1 per cent. phosphorus in the iron.

The author prepared a series of test mixtures of known constitution, varying from 1 per cent. to 0.020 per cent. phosphorus, in order to prove the accuracy of the method, and gives the following table of results:

Known composition.	New method.	Old method with molybdic acid.
1.000	0.990	1.005
0.100	0.105	0.110
0.020	0.025	0.021

Three samples of iron were analyzed according to the old and new process. A, soft cast iron; B, white cast iron with 12.5 per cent. manganese; C, steel. Phosphorus obtained:

	A	B	C
According to new method..	1.052	0.185	0.035
With molybdic acid.......	1.020	0.185	0.030

As Kessler's method enables us to dispense with the highly expensive molybdic acid, and appears to give accurate results, there would appear to be no objection to its general adoption. A ready way of determining phosphorus in ores has become of great importance since the introduction of the Bessemer process, and the above treatment may supply the want that has been felt by our ironmasters.—*Railway Times.*

Patent Heating Furnace at the Round Oak Works.—The agent for the Earl of Dudley, at the Round Oak Iron Works, Staffordshire, has lately been testing a heating furnace, patented by Mr. Andrew Howatson, late of Messrs. Baird's works, Muirkirk, Ayrshire, in the 12 in. mill. The process consists of introducing heated air instead of cold air, as formerly, into the ash-hole. The air is heated by its being allowed to pass round the bottom of the stack, and under, and at the back of the furnace itself. It is supposed that the air is by this means heated to a temperature of 600 deg. The back of the ash hole and the firing hole are securely fastened up by air-tight doors, so that no cold air whatever is allowed to pass into the furnace. The consequence of this is, that the iron is not "cut away," or wasted through raw air entering through the firing hole and bridge. The results so far have been satisfactory. Tests have been made—the iron and coal being weighed into this furnace, and to one on the ordinary principle facing it, both furnaces being previously put in first-class repair. In two "turns" working, a saving was shown of 4 cwt. 1 qr. 23 lbs. weight of iron; the total of coal saved was about 14 cwt; and 9 cwt. 2 qrs. 23 lbs. less of cinder were made in the two "turns" working under the new process—proving a saving in iron and brickwork, etc. The furnace has now been at work nine weeks, and has not had any repairs done to it beyond a new bridge; and the proprietors and managers are so satisfied with it that they are putting down another in their 8 in. mill.

Cost of Making Missouri Iron.—A writer in the "St. Louis Democrat" states that during the past year the average cost per ton of making iron at Carondelet has been as follows: 2½ tons of coal, at $4.35 per ton; 27 bushels of Connellsville coke, at 18 cents per bushel. This reduced to raw coal would make 3½ tons, at $4.35 per ton. Iron Mountain ore, 1⅔ tons, at $5.50 per ton. To this add labor, $4.31, interest $1.14, expenses $1.50, limestone 27 cents, and we have a total of $31.71 as the cost per ton of all pig metal made at Carondelet. This cost of making iron, the writer says, leaves no margin for the capital invested, or the very great uncertainties of a blast furnace. It shows, that, while the labor and interest accounts are small comparatively, the fuel and ore cost more than three-fourths. He goes on to say further: "In Missouri, we pay 2⅓ cents per ton per mile for transporting iron ore, while in Pennsylvania it costs only 1 cent per ton per mile. There is a monopoly at present of iron ore and fuel, but the railroads now being built will place the iron men in a condition to bring competition to bear on this matter."—*Am. Railway Times.*

The Bessemer Steel Works of the Chicago Union Rolling Mill Company commenced operations on the 28th ult. The steel works building is 336 by 124 ft., erected at a cost of about $300,000. The pig iron used is made by the Company at Knightsville, Ind., from a mixture of Missouri and Lake Superior ores. We understand the Company has orders on hand for all the steel rails that can be turned out this year.

In that portion of France that has just been annexed to Germany, there are 200 blast furnaces and 160 puddling furnaces; their production of rails and iron of every kind amounts to about 140,000 tons per annum. Other French groups will, probably, make good the deficiency thus occasioned in the national production of France. The Nord will manufacture rails, the Muerthe will produce pig, the Haute Marne, rails and pig, and the Ardennes, manufactured iron.

RAILWAY NOTES.

The Trans-continental Trip.—We took advantage during the month of August of the opportunities offered for making the great American tour across the continent. We followed first those lines of travel which lead most centrally through the States which lay on the route. From New York we went by way of the New Jersey Central directly across to Easton, and from thence by a route under the same excellent management, by way of Allentown to Harrisburg, Pa. The Pennsylvania Railroad bore us to Pittsburg, and the Pittsburg, Fort Wayne and Chicago delivered us safely at the great metropolis of the West in 33 hours from New York.

The attractions which this route possesses for the tourist who is bent on observation are numerous. The scene is never dull. First is presented the most thriving portion of New Jersey: pleasant villages, whose prosperity is mostly due to a liberal railroad policy; a picturesque, undulating surface, with frequent woodlands, whose delightful variety of foliage is not to be matched on any other portion of the whole route to the Pacific; frequent streams of clear water, indicating a region of abundant rains; well-made roads, and on nearing the west border, evidences of iron mining and manufacture.

The passage of the Delaware affords such an ex-

hibition of iron bridges of the rectangular truss variety, that the fine view to the south is apt to be passed without notice.

The Lehigh valley and its busy blast furnaces, the pleasant towns of Bethlehem and Allentown, the broader slopes and larger cultivated areas of the Keystone State, are the noticeable features of the line to Harrisburg.

From this point the route over the Alleghanies is full of the picturesque. Going west we passed the summit in the night, but on returning, although we had been revelling in the glories of the Yosemite by sunlight and moonlight, we experienced a fresh pleasure in the glimpses of wooded mountain scenery afforded on the east slope of the mountains. The "observation car" is just as desirable here as in Weber Cañon or the passage of the Sierra Nevada.

Ohio and Indiana are cut quite centrally by the route through Fort Wayne. The section was once the Far west, and was a marvel of productiveness to the New Englander. The traveller will not fail to notice the changes in the physical features; the absence of rocks or gravelly soil; less variety of forest trees; increasing flatness of surface as he goes west; a scarcity of streams, and the few he sees are muddy and slow; and at last, the true prairie.

In nearing Chicago, the river region of the Ohio and Mississippi is left, and the traveller, without passing a ridge or any conformation that bears the appearance of a divide, enters the hydrographic region of the great lakes and their outlet, the St. Lawrence.

The chief attractions of Chicago need not be enumerated here, two or three days may be profitably spent in and about the city. The engineering works have now a world-wide reputation. The last one, without being a great work, is a novelty, and a funny one at that. The Chicago River, which formerly emptied in the orthodox way into the lake, has been reversed; its mouth has become its source, and it now flows, bearing the waters of the lake and the rinsings of this enterprising city, through its former head into the Mississippi River.

From Chicago through Burlington and Quincy, and thence to Kansas City, we found abundant verification of the current accounts of the fertility and abundant mineral resources of Illinois and Missouri.

The bridges of both crossings of the great rivers have been fully described in our columns. The Eastern tourist may share in the pride of the Western resident if he be only an American, for they are essentially American works. In testimony of the smoothness of this portion of the road we may state, that a choir was extemporized in the Pullman car through the efforts of the conductor, aided by a fine parlor organ, which formed a part of the equipment of the car, and that through the afternoon ride familiar songs were sung by people throughout the car, as undisturbed by the common turmoil of travel as though they were in a drawing room.

Kansas City is in such an actively growing condition, that one feels at the first glance that it has increased somewhat since yesterday and will grow sensibly before to-morrow. It is geographically a Missouri town, but the whole West and Southwest may some day claim a right to be proud of it.

Beyond the great rivers one may claim to be in the Great West. The Kansas Pacific Railway, starting from this point, leads along the wonderfully fertile valley of the Kansas River, through a section singularly rich in such resources as the new settler finds most desirable. The corn of the valleys seemed more like a forest than an agricultural crop. The green slopes of the gentle undulations were only less fertile than the river bottoms. Stone, so useful in all kinds of structures, lies in beds *above* the level of the plains, as if designedly stored so as to facilitate quarrying and transportation.

The increase of elevation is quite gradual, but the ascent to the great backbone of the continent begins at the Missouri River, and at the westerly boundary of Kansas the railroad has an elevation of 4,000 ft. The plain, or plateau rather, is drier at this high elevation, and the buffalo grass grows sparsely. At the elevation of 1700 to 1800 ft., the herds of cattle, and for long distances, immense herds of buffalo, testified to the nutritious qualities of the short dry-looking grass.

Before reaching Denver the great wall of mountain to the west plainly indicates an entire change of surface configuration.

Denver, although something more than 5,000 ft. above the sea, is without doubt well located, and is destined to become an important, if not a great city. The rainfall is not abundant, but a supply of water is readily obtained by carefully utilizing the springs and streams from the near mountains. The city is growing with great rapidity. The narrow-gauge question is being practically tested by a road of 3 ft. gauge already running its construction trains. Rolling stock of all kinds was on the tracks ready for the regular routine work of daily traffic. Many more such roads will doubtless radiate from the same centre to the mining localities for which Denver will always serve as a principal base of supplies. Aside from its commercial importance, however, Denver is already an important objective point for the tourist; lying between, and on the only route joining the buffalo plains and the Rocky Mountain Parks, it is the gathering place of sportsmen as well as pleasure tourists.

The Kansas Pacific Railway, of which we take leave at Denver, seems, to such inspection as we could make, a model of good management; its termini are the two most rapidly growing cities of the West; and, aided by the mining and agricultural resources of the sections within its reach, its future continued success seems certain.

The Denver Pacific Railway, 100 miles in length, connects the western terminus of the Kansas Pacific with the Union Pacific Railway. It runs approximately parallel with the mountains. The experimental town of Greeley is the one point of interest on the route. An attempt is being made to cultivate the high plains here by aid of irrigation from the mountain streams.

The present success affords the highest encouragement for the future.

It will be of great service to the mining region if successful agriculture becomes an accomplished fact at Greeley.

Cheyenne is the junction of the great lines of travel. There is nothing to be said of the town at present, and we discover no signs of growth.

From Cheyenne west the Union Pacific road rapidly rises to the highest railway station in the world, Sherman, 8,2 2 ft. above the sea. For 450 miles the line of the road is more than 6,100 ft. high. This is the great plateau of North America.

The Rocky Mountains are barely visible when crossing the culminating point. Much of the region bordering on the road is quite flat, and in many places where water has been obtained, quite fertile. Laramie Plains afford good crops. Corn, clover, and fruit trees were flourishing at Humboldt; where springs in the mountain near at hand had been conducted by pipe distribution to the fields near the station. The experiment is capable of repetition, without doubt, in many more places where now nothing grows but sage bush.

The mountains crowd upon the road as it descends from the high plateau to the basin of Utah. The scenery for several miles is exceedingly wild. The rocks, sometimes massive, and occasionally exhibiting slender and grotesque forms, afford abundant opportunities for the enjoyment of the picturesque. The railway management have thoughtfully supplied an open observation car for the accommodation of passengers through this portion of the route.

At Ogden begins the Central Pacific Railway. It is also the northern terminus of the Utah Central Railway; the principal importance of which is, that it affords an easy access for modern civilization to the great centre of Mormonism. He who would see Salt Lake City as it was under strict Mormon rule, must go soon.

At Ogden begins the Central Pacific Railroad. It traverses for several hundred miles the great central basin of the continent. The rivers have no outlet; the rainfall is exceedingly scanty, and to the eye of the casual observer there is no promise throughout the *desert* of any agricultural product. The fact of the rivers, however, suggests a possible irrigation when near enough to the mountains; and such towns as Salt Lake City, Ogden, and Corrinne, prove the possibility of raising many kinds of food crops in fair abundance. At present, however, the mining interests are the most important on the line of the road throughout Utah and Nevada The student of Physical Geography or Geology must regard this desert with intense interest.

The road is well built, and is kept in an excellent state of repair.

The passage of the the Sierra Nevada exhibits some fine railway engineering.

The location of this portion of the route must have required unusual skill. The observation car is called into requisition here, and the occupants are invariably thrilled with the sight of the frightful precipices along the edge of which the car glides in its descent of the mountains.

The gold mining operations here are quite active on both sides of the road for many miles. The operation of hydraulic mining may usually be witnessed by the passengers on the train, but in our passage through the section it was the driest month in the driest of years, and the streams had refused their supply.

Sacramento is reached in $6\frac{1}{2}$ hours from the highest point in the Sierras. This city is worthy a longer visit than we could give it. In our estimation, the look of substantial prosperity which it presents throughout affords a more just cause of pride in American pluck and enterprise than any other city of the States. It is to be remembered that its present prosperity was assured while it was *not* on a highway of commerce, but that the same persistence and energy that built the city bent the national highway to its borders, and then directed it over the mountains by a path which American engineers will always regard with just pride.

The proper thing for the tourist to do when in Sacramento is to make his preparations for the Yosemite trip. If economy of time is regarded, this offset from the line of travel had better be made here or Stockton than at the terminus, San Francisco.

The traveller needs only one bit of advice and information not given in the printed circulars: that is, to take the least possible baggage into the valley. The so-called roads and trails leading into it are not the results of invention or manufacture in any sense, but only of discovery. To accept the term *road* as applicable to such trails as our stage driver conducted us over, is to make a large concession in scientific nomenclature.

The grandeur of the Yosemite is indescribable. It is a specimen of Nature's engineering, so vast as well as so unique that it seems to offer no suggestion to human invention. Another year it will be more accessible to tourists. The Central Pacific Railway will push its branch so far eastward this fall, that the stage ride will be materially lessened. It requires now about 8 days as a minimum in which to do the Yosemite, counting from the first departure from the Central Pacific at Lathrop to the re-arrival at the same point. San Francisco is reached in 4 hours more, and the trans-continental journey is completed. To be theoretically exact in the matter, we embraced an early opportunity offered us and indulged in a ride to Cliff House, whose balconies overhang the Pacific Ocean; thence along the beach 2 or 3 miles, and we again turned our faces homeward.

Under the guidance of the former Surveyor-General, Hon. J. Franklin Houghton, we were able to see much of the city that otherwise would unavoidably have been omitted.

We could not stay to sound the depths of the proffered hospitality of Californian friends. We can only say that the kind offers were such as are known to be characteristic of this great Western State, and seem somehow prompted by its immense resources.

Seated again by the window of a "silver palace car" we watched the panorama of the continent as it turned backward. California, Nevada, Utah, Wyoming, were produced successively without any hitch in the machinery. At Cheyenne we deviated from our westward route and continued on the line of the Union Pacific Railroad to its terminus, Omaha.

Through Nebraska the line follows the valley of the Platte, and the gradually increasing fertility as the eastern border is approached, makes an agreeable picture after the sterility of the desert. At Omaha the richness and productive power of the soil seem to culminate; high ground and low seem equally good.

The city itself offers the advantages of the most advanced enlightenment. The choicest spot in the city is occupied by the High School Building, a structure that we should find it difficult to match in our Eastern cities.

In continuing eastward, the smoothness and rapidity of our transit was such, that we took our breakfast in Iowa, dinner in Illinois, supper in Indiana, breakfast next day in Ohio, and dinner in Pennsylvania.

From the Pacific to the Atlantic we arrived at every station "on time," or so near it, that the difference was not noticeable.—[Ed.]

As the prosperity of the iron trade of the country depends so largely upon the development of our railroad system, the following facts from "Poors' Railroad Manual" for 1871, will be interesting, particularly as they come from a source so reliable and intelligent:

"The railroad first constructed in the United States was the Baltimore and Ohio, of which 23 miles were opened for use in 1830. It was for two years thereafter worked by horse-power. The following statement will show the number of miles opened each year since the date:

Year.	Miles in Operation.	Annual Inc. of Mileage.
1830	23	....
1831	95	72
1832	229	134
1833	380	151
1834	633	253
1835	1,098	265
1836	1,273	175
1837	1,497	224
1838	1,913	416
1839	2,302	389
1840	2,818	515
1841	3,525	707
1842	4,026	491
1843	4,185	159
1844	4,377	192
1845	4,633	256
1846	4,939	297
1847	5,599	669
1848	5,996	397
1849	7,365	1,369
1850	9,021	1,656
1851	10,982	1,961
1852	12,908	1,926
1853	15,360	2,452
1854	16,720	1,360
1855	18,374	1,654
1856	22,017	3,643
1857	24,508	2,491
1858	26,968	2,460
1859	28,789	1,821
1860	30,635	1,846
1861	31,256	621
1862	32,120	864
1863	33,170	1,050
1864	33,908	738
1865	35,185	1,277
1866	37,017	1,832
1867	39,244	2,227
1868	42,277	3,033
1869	47,254	4,999
1870	53,399	6,145

"The number of miles constructed in the decade ending in 1840, was 3,513; in that ending with 1850, 5,508; in that ending with 1860, 21,614; and in that ending with 1870, 22,764. The greatest number of miles constructed in any one year, was in that just passed, in which 6,145 miles were opened. The mileage constructed in 1869 and 1870 equalled 11,144 miles. The progress of railroads, as will be seen by reference to accompanying tables, was seriously interrupted by the war of secession. During the four years of its continuance only 3,273 miles were opened—2,872 miles less than were opened during the past year. In that period only a very small extent of mileage was constructed in the Southern States. Within the past two years, great progress has been made in these works in that section of country.

"Of the ultimate extent of railway mileage to be constructed in this country no safe estimate can be made It is likely to increase very rapidly for many years to come. The progress made will depend largely upon the amount of increase of our population; but as the same number of people double their traffic to these works every ten years, railroads will, for a long time, make rapid progress even in those States whose population is comparatively stationary. The State of Massachusetts has one mile of railroad to 5.27 square miles of territory. A similar ratio would give to the States of New York and Pennsylvania 9,000 miles of line respectively, or more than twice their present mileage. It would give to the state of Illinois nearly 11,000 miles, or two and a half times its present mileage. In each of these States, the construction of railroads will proceed rapidly till the ratio of Massachusetts is reached. The same may be said of other States having, in the aggregate, an area of 500,000 square miles. When a mileage of 100,000 miles is reached, the same necessity will be felt for the continued construction of these works that now exists.—*Bulletin of the American Iron & Steel Association.*

Brazilian Railways.—The railways and tramways already constructed in Brazil have an extent of 812,777 kilometres, exclusive of the Pará and Alagoas tramways, namely:

D. Pedro II	260,480	kil.
Valenca branch	25,000	"
Santos (S. Paulo)	139,600	"
Bahia	123,500	"
Recife and S. Francisco	124,900	"
Cantagallo	49,100	"
Mauá	17,500	"
Apupicos and Caxanga (Pern.)	8,755	"
Recife to Olinda (Pern.)	8,000	"
Botanical Gardens (Rio.)	13,123	"
S. Christovam	42,779	"

In Construction.

Dom Pedro II	160,000	kil.
Cantagallo	35,000	"
Gundiahy to Campina	43,000	"
" to Itú	69,000	"

Total, ready 812,777 kil. In construction .... 307,000 kil.

Besides this, about 1,500 kil. have been given in concession or are under survey.

The Pennsylvania Railroad Company.—Prominent among the gigantic corporations of the present day, and the still more stupendous ones whose embryotic buds are not yet quite unfolded to the public gaze, stands the Penn. R. R Co. Created originally for facilitating intercourse between the extremes of Pennsylvania, it has constructed from its eastern to its western terminus from Philadelphia to Pittsburg—one of the most thoroughly built, perfectly equipped, and admirably directed railways in the United States, if not in the world. Having its termini located on the navigable watters of the Delaware and the Ohio, and controlling many of the lateral roads, it has open to it the traffic of the world. Possessing such great carrying capacity that its local traffic could not adequately employ it, its managers, yielding to their natural business instincts, have stretched out new iron ligaments, uncontrolled by State boundaries, to

every quarter from which traffic could be gotten or created, to feed the trunk line. Thanks to this policy, it draws support through the absolute control of other roads, reaching to the great inland seas of the North; and, unhindered by the "Father of Waters," which it taps at several points, it already reaches Omaha, and is perfecting its connections to secure the carrying trade of the vast cotton fields of the South. Finally, arrangements are in progress by which, if not thwarted by the law, its eastern terminus will be transferred to immediate proximity to the Atlantic Ocean, while the early future will witness this control extended to the Pacific.

It is thus that a road less than 400 miles in length, less than a quarter of a century old, through the vitality and energy of its managers, controls, operates, and renders tributary to itself other roads extending from the Atlantic to the Pacific Ocean, and from the northern lakes to the Gulf of Mexico.

An examination of the annual reports of this Co. shows something of its present and prospective strength. These reports for a series of years show the following results :

——	Liability.	Profits.
1862	$35,324,214	$4,942,753
1863	38,295,668	5,081,196
1864	45,520,336	4,020,019
1865	45,856,799	3,819,654
1866	44,251,596	3,578,741
1867	46,100,425	3,905,054
1868	54,143,745	5,289,339
1869	65,030,302	5,022,825
1870	73,097,215	6,012,991

Narrow-gauge (3 ft.) Passenger Locomotive, by the Baldwin Locomotive Works, for the Denver & Rio Grande Railway.—This locomotive, with two others for freight service, has just been completed at the Baldwin Locomotive Works, and by the time this meets the public eye will undoubtedly be at work on the pioneer narrow-gauge line in the United States. As this machine is entitled to the designation of the first narrow-gauge passenger locomotive built or operated in this country, a brief description of it will be of interest both to the railroad and general public

Its dimensions are as follows :

Cylinders....9 in. diam.
Stroke of piston ....16 in.
Diameter of driving wheels....40 in.
" " pony wheels....24 in.
Distance between centre of pony wheels and centre of front divers....5 ft. $8\frac{1}{2}$ in.
Distance between driving-wheel centres ....6 ft. 3 in.
Total wheel-base of engine....11 ft. $11\frac{1}{2}$ in.
Rigid wheel-base (distance between driving-wheel centres)....6 ft. 3 in.
Capacity of tender....500 gal.
Diameter of tender wheels....24 in.
Distance between centres of tender wheels ..6 ft.
Total wheel-base of engine and tender....26 ft. $5\frac{1}{4}$ in.
Length of engine and tender over all...35 ft. 4 in.
Weight of tender empty....5,000 lbs.
Weight of engine in working order....25,300 lbs.
Weight of engine on drivers ....20,500 lbs.
Weight of engine on each pair of drivers....10,250 lbs.
Weight of engine on pony wheels.... 4,800 lbs.
Height of smoke stack above rail....9 ft. 9 in.
Height of cab from foot-board to centre of ceiling....6 ft. 3 in.

It will be seen that the rigid wheel-base is given as 6 ft. 3 in., the distance between centres of driving wheels. This is due to the fact that the leading or pony wheels are fitted with a swing bolster and radius bar, allowing them to move laterally under the engine in passing curves. These wheels are also equalized with the front pair of drivers. By this arrangement, while the pony truck assists in guiding the engine on a curve and so relieves the front pair of drivers from the excessive wear of tires which would otherwise result, the rigid wheel-base is reduced so that the engine will pass curves of very short radii without difficulty. It is, in fact, only about $\frac{2}{3}$ that of the 4-wheeled cars designed and built for the same road.

As much interest attaches to the subject of the speed practicable on narrow-gauge roads, we may remark that the proportions of this machine are such that it develops the same total travel of piston in going one mile as does a locomotive having 24 in. stroke of piston and driving-wheels 5 ft. in diameter. It is therefore apparent that equal, or nearly equal, speeds are possible with this engine as with the engine of the usual pattern on the full gauge. *i. e.*, 24 in. stroke and 5 ft. drivers.

The plan of this engine gives somewhat more than $\frac{4}{5}$ of the whole weight on the drivers, so utilizing it for adhesion. Its tractive power on a good rail, exclusive of the resistance of curves, is as follows :

On a level....512 gross tons.
On a grade of 40 ft. to the mile ...164 " "
On a grade of 80 ft. to the mile.... 98 " "

From these figures should be deducted 17 gross tons, the weight of the engine and tender in working order, to get the total weight of cars and lading which can be drawn on a level or on the grades named.

The freight locomotives built for the same road have three pairs of drivers and a swing-bolster pony truck. Their cylinders are 11 in. diameter and 16 in. stroke ; drivers, 36 in. The total weight of engine in working order is 33,500 lbs., of which about 29,000 lbs. are on the drivers. Being distributed to 3 pairs of wheels, the weight on each pair of drivers is a little less than 10,000 lbs., nearly the same result as with the passenger engine.

We hope to give a full description of the freight locomotive also at an early day.—*Railway Review.*

The Rhigi Railroad.—This interesting mountain line, which, being only $4\frac{1}{2}$ miles long in that space overcomes an elevation of 3,770 ft., was opened for traffic on the 22d of May last, a trial trip, with perfect success, having been made the day previous. The following description is from the Directors' account :

"The whole length of the railway from the above-mentioned Vitznau to the frontier of the Canton of Schwyz, at Staffelhohe, is $5\frac{1}{4}$ kilos, or 16,140 ft., the vertical height of the last-named place above the level of the lake being 1,113 metres. The run of the straight lines is 3,417 metres, and that of the curves 1,724 metres, the latter

having a radius of 189 metres. With the exception of a short horizontal slip of 45 metres at the Vitznau station, and one of 39 metres at Staffelhohe, the whole line consists of gradients, the maximum being 25 in 100, the minimum 6.6, and the average 22. In addition to the two terminal stations, it is proposed to make a water station, with sidings, to allow other trains to cross or pass at Freiberg, half-way up the mountain, another at Folsenthor, and a third at Kaltbad. The most remarkable objects of engineering work on the line are the cutting in the rock just above Vitznau, the tunnel at Schnurtobel, the bridge over the chasm at the same place, and the cutting at Eichberg. The rolling stock at present consists of 3 locomotives, which are differently constructed from those used on more level ground, inasmuch as they have upright boilers, and their driving axles are furnished with cog-wheels, which secure them a firm hold or grip on a cogged rail – 3 large passenger carriages, with accommodation for 54 persons each, and 2 smaller ones fitted with 30 seats each. The Company's capital of 1,220,000 francs, all paid up, was found insufficient to cover the total expenses, which have amounted to 1,501,897 francs ; the excess, caused partly by an alteration and extension of the original plans and estimates, and partly owing to the difficulty of obtaining the needful number of skilled workmen, in consequence of the disturbed relations between the neighboring States of France and Germany, had, therefore, to be raised by a small loan on mortgage, to be repaid out of the receipts of the line in certain stipulated proportions according to the annual amount of the earnings."—*Railroad Gazette.*

An Underground Railway.—Lancaster, Pa. is the first city in the United states to put an underground railway into practical operation. It is not so large as the Metropolitan of London, but serves its purpose, and is due to the energy of one manufacturer entirely. The railway in question is in a tunnel running between the cotton mills Nos. 2 and 3 of Mr. John Farnham, of Philadelphia, the sole proprietor of these mills. This tunnel connects the tower of mill No. 2 with that of No. 3, and runs under Prince street, a total distance of 180 ft. in length. It is intended to economize labor and expedite the transmission of goods from one mill to another. For this purpose a railroad is laid in the tunnel on which a platform car will be run. The tunnel, is arched with brick, is 7 ft. high and 6 ft. in width, and, as above stated, 180 ft. in length. A great convenience in the handling of goods will thus be afforded by a little engineering skill. The mills connected by this underground railway employ no less than 900 hands, including men, women and children.—*Iron Age.*

ORDNANCE AND NAVAL NOTES.

The Navy.—In consequence of the Agincourt having been saved from her perilous position, the Achilles and other ships which were ordered to proceed to her rescue have been recalled, and will return to their ordinary stations. The promptitude with which the Achilles got away from Portland proves the value of the present system of reserve. The Captain Committee stands adjourned for a fortnight from Thursday, when it will again meet, and no doubt shortly afterwards will conclude its labors. Dr. Minter, of the Royal yacht, has been nominated to succeed Deputy-Inspector of Hospitals and Fleets W. T. Domville, at Malta Hospital. We understand that Dr. Minter's appointment has been made at the request of the Court, and that the authorities now in office could not reasonably refuse to comply with a wish of the kind.—*Army and Navy Gazette.*

Shipbuilding has long been carried on in Belfast with varying success. Recently there were 3 iron ships on the stocks together, being constructed by the firm of Messrs. Harland & Wolff, successors to a previous firm, who were also much engaged in shipbuilding. Messrs. Harland & Wolff gave employment to several hundred hands, and some of the screw steamers of the Royal Navy have been built by them. In a few years more, if shipbuilding does not decline as a British trade, Belfast will probably afford greater and fuller facilities for shipbuilding, from its increasing harbor improvements.

Her Majesty's Ship Devastation.—This great turret frigate was formally launched at Portsmouth dockyard lately. The Devastation is the first of her class afloat as a sea-going monitor, carrying 35-ton guns, and clothed with thicknesses of 14, 12, and 10 in. armor, and is, therefore, looked upon as a triumph of the turret over the broadside principle of carrying guns of exceptionally large calibre at sea.

Greenock Harbor.—The foundation-stone of a new graving dock was laid at Greenock a few days ago. The site of the undertaking has cost £80,000. The dock, with pumping machinery and caisson complete, will cost £50,000, and the temporary and outer works £18,000. The contract is expected to be completed by the spring of next year. As showing the rapid increase of the shipping traffic at this port, it may be stated that the harbor revenue in 1836 was £11,637; in 1861, £25-000; and this year was estimated to be £53,000.

The German Navy.—Great additions to the strength of the German fleet are contemplated. Besides the 3 turret-ships, 2 of which are to be built at the Royal Docks at Kiel, and 1 probably by the Stettin Company Vulcan, 7 corvettes are to be constructed at the Royal Dockyard of Dantzic. Four of these are to be of the size of the Ariadne, and 2 of that of the Alabatross. The seventh corvette, to be built at Dantzic, is the Louise.

Turkish Torpedoes.—About 300 torpedoes are said to be now sunk at the Black Sea mouth of the Bosphorus, and the strait is believed to be impassable by a hostile fleet.

Admiral Pothuau has ordered 4 steam despatch boats to be sent from Toulon to guard the coasts of New Caledonia.

It is said that Mr. Rowsell is to be placed at the head of the Store and Purchase Departments of the Navy, which it is believed will be shortly amalgamated.

Indian Harbors.—Mr. Robertson, the marine engineer dispatched by the Duke of Argyll to examine the condition and capabilities of Indian harbors, has sent in his report on the following

places: Mangalore, Cannanore. Calicut, Beypore, Narakal, Cochin, Allepy, Quilon, Tuticorin, Negapatam, Porto Novo, and Coconada.

After having undergone considerable repairs on the patent slip at Capetown the steamship Gambia became a total wreck in Algoa Bay.

ENGINEERING STRUCTURES.

Brazilian Telegraphs.—The Government telegraphic lines of Brazil have a total length of 2,080 kil. The longest line is the one between Rio de Janeiro and Porto Alegre, near the frontier of Uruguay.

The line betweeen Rio de Janeiro and Pernambuco is under construction, and will be 2,023 kil. long. Its cost is estimated at $464,000—$180,000 being for labor, and the rest for wire, etc. Posts of iron are to be used, as the wooden ones have proved a failure in Brazil. The Government telegraph service cost in 1870 $141,000, including outlay for material for repairs and extensions. The number of telegrams transmitted was 45,792. The receipts, $55,200.

The "International" (Buffalo) Bridge.—The Buffalo "Advertiser" gives the following graphic account of the immense difficulties encountered in this work:

"In spite of untiring and patient labor a succession of obstacles have been met that must seriously retard the work. By a sudden fall in the water level, owing to a strong wind off shore, the fifth caisson, which was being sunk in 45 ft. of water, settled to the bottom of the river, lowering about 12 in., and was forced by the current slightly out of proper position. The difficulty was not so great that any serious trouble was anticipated, and a rise of water would have placed the crib in such shape that the correct line could have been reached. But ill luck seems to attend the location of this crib, and the next day it was evident that the structure was getting badly out of line. The crib rested on a gravel bed, about 5 ft. in depth, and the strength of the current, even at the bottom of the rapidly moving river, was so great that the gravel was being sucked out from underneath. Nothing was to be done but to go over the task, discouraging as it might seem. The concrete filling of the crib will have to be removed, the structure again placed in line and sunk to a solid bottom. We do not know, but suppose that the bottom of the river at that point will have to be prepared for the reception of the structure. No one can fully appreciate the difficulty attending a work of so extensive a character without visiting the spot. Old Niagara rushes by with a 7-mile stride at the point where the bridge is to cross, and to oppose so powerful an agent as water, when compressed within bounds and driven by superhuman force, to say nothing of overcoming accidents from other sources, has proved a hard task indeed. When the structure is completed, and the United States and Canada shake hands over the noble stream that flows past our city, the work will stand as another proof of what mechanical skill and patient dint can accomplish."

The Detroit Tunnel.—The Detroit "Post" states upon authority that work upon the river tunnel will be commenced at once. All the money required has been secured, and organizations have been effected on both sides of the river, which in due time will be consolidated. Mr. Cheesebrough, the engineer of the lake tunnel at Chicago, will have charge of the work.

The plan contemplates really a series of 3 cylindrical tunnels. Two of these will be for road purposes, each being 18½ ft. interior diameter. They will be parallel and 50 ft. apart. This plan is deemed preferable to a single tunnel with double tracks, both on account of less liability to accidents and delays, and on account of strength and economy. The 3d tunnel will only run under the river; will be below and midway between the others; is designed for drainage only, and will have an interior diameter of 5 ft. This 3d tunnel will be constructed first, in order to fully develop the character of the soil, and to drain the other 2 as the work progresses. It is expected that the building of the lower tunnel will fully determine the feasibility of the entire project, and this will, therefore, be completed before work is undertaken on the road tunnels proper. If difficulties are met with anywhere, the drainage tunnel will be likely to encounter them, and their nature can then be determined before any great expense is incurred.

Work will be first commenced on the grounds of the Det. & Mil. R. Co., near the foot of St. Antoine street. Here a shaft, 10 ft. in diameter, will be sunk, and excavating under the bed of the river will proceed from that point. As the excavating proceeds, a shell of brick masonry will be constructed in a permanent manner. By the time the middle of the river is reached, if the project still appears feasible, operations of a similar character will be commenced on the other side, and the work will proceed from both directions. The building of this experimental and drainage tunnel, it is expected, will not take more than 2 or 3 months, so we shall soon know whether the proposed tunnel is possible. On the successful completion of the first, work upon the others will be immediately begun and proceeded with, with all possible dispatch. The engineer estimates that 1½ or 2 years will be required to complete the work. Of course much depends upon the results ascertained in the experimental tunnel. If it shall appear that the larger tunnels can unquestionably be built without danger or delay, the work will be pushed with all possible dispatch, and probably completed within a year.

The entire length of the tunnel, not including the approaches, will be about 2 miles, and its estimated cost nearly $3,000,000. When completed it will be used by all roads entering the city.

NEW BOOKS.

Model Drawing, Containing the Elementary Principles of Drawing from solid form, the Method of Shading, and Pattern for making Drawing Objects in Cardboard. By Ellis A. Davidson. London: Cassell, Petter & Galpin. For sale by Van Nostrand.

This is another little volume belonging to the series which Mr. E. A. Davidson has from time to time written, and which Messrs. Cassell, Petter & Galpin have published. The previous volumes we have noticed as they appeared, and the same favorable criticism awarded to the previous volumes may be extended also to this. It is specially

intended to accompany a series of models of different elementary forms, by the aid of which an almost infinite variety of lessons may be given to the student, and the book, which, however, may be equally well studied without the models aforesaid, and which, by the way, seem to be unnecessa[illegible]ge, lastly, contains also practical directions to the student for enabling him to construct models for himself out of cardboard. As with the previous books, the present is divided into a number of simple problems, each of which is progressive, and is fully and clearly demonstrated and worked out. The combination of cubes, cylinders, cones, etc., afford a most excellent means of instructing the pupil, not only in geometrical, but also in perspective drawing; and though Mr. Davidson's book is full of useful information, it but indicates a small proportion of what may be done by the aid of the models.

Mr. Davidson is a thoroughly good teacher; moreover, he is able to place his instructions clearly and plainly upon paper, and the youngest and most inexperienced of his students cannot fail to realize the full amount of benefit from this book. We recommend it to all would-be draughtsmen; its price, three shillings, places it within the reach of all, and, taken in conjunction with the rest of the series, cannot fail to be a most valuable addition to the student's library. We suppose it will be followed by others upon the projection of shadows, etc.

A Practical Treatise on Coignet-Béton, and other Artificial Stone. By Q. A. Gillmore, Bvt. Maj.-Genl. U.S.A. New York: D. Van Nostrand.

The subject of artificial stone is of constantly increasing importance. The undoubted success of the Coignet-Béton in the hands of the French engineers and artists, has prompted a vast number of experiments upon mixtures of lime, cement, and sand, by would-be inventors, who have announced, after brief trials, an unqualified success. The record of the failures of incautious builders who have trusted to these empirics, is not a pleasant one.

It is particularly gratifying to get at this time, from the hand of a thoroughly practical engineer, a report of his own careful observation and experiment upon artificial stone. The treatise will be regarded, among American engineers, as of the highest known authority. The author's previous labors in a similar direction, have paved the way to such a reputation.

The present work treats of Coignet-Béton, Ransome's Silicious Concrete Stone, the Frear Artificial Stone, the American Building Block, the Sorel Artificial Stone, Portland Stone.

Numerous experiments upon tensile and crushing strength of these building stones are carefully tabulated.

Nine plates illustrate the first article, this being one of the series of professional papers submitted as reports to the War Department.

Gymnastic and Technical Education. By Francis H. Smith, A. M., Superintendent, and Prof. Mathematics and Moral Philosophy in the Virginia Military Institute. New York: D. Van Nostrand.

This is a lecture delivered on the occasion of reopening the Institute for the Fall Session of the present year.

The lecturer dwells not upon the details of the curriculum, upon its desirableness. In the race for superior excellence among our technical schools, the Military Institute is doubtless destined to take a high stand, and it will do so chiefly through the labors of her able superintendent.

It was in this institution, we believe, that the idea was first projected of practical experimentation in general physics, as a systematic course of training.

Prof. Smith's pamphlet deserves many readers.

A Practical Treatise on the Condensation of Steam. By N. P. Burgh. London: E. and F. N. Spon. For sale by Van Nostrand.

The introduotion to this work contains a history of the methods of condensation of steam from 1705 to 1838. Then follow 15 chapters descriptive of condensers for various kinds of engines, including locomotives. The two concluding chapters are devoted to general principles, and to rules and formulas.

Upwards of 200 engravings illustrate the work. Mr. Burgh's former works have already introduced him to the engineers of the country, and he needs no more favorable notice at our hands.

Spon's Dictionary of Engineering. London: E. and F N. Spon.

This work is coming forward with satisfactory rapidity; the last number received probably finishes the articles under G.

The late numbers fully redeem the promise of completeness made in the beginning. The illustrations are most ample, and embrace the latest contributions to practical engineering.

The buyer can obtain the parts thus far published, in four octavo volumes, or in two, as he chooses. For sale by Van Nostrand.

Switches and Crossings. By Wm. Donaldson, C. E. London: E. and F. N. Spon.

This gives formulæ for lengths of switches, angles of crossings, and distances of crossing points, and heels of the switches from the springing of the curve.

The formulæ are expressed in algebraic terms only. Six plates illustrate the text. For sale by Van Nostrand.

A Treatise on Ventilation. By Lewis W. Leeds. New York: John Wiley and Son.

This is a course of lectures, delivered by the author before the Franklin Institute. The present work is an enlargement of the edition of 186[illegible], containing about four times the amount of matter. Nothing could be clearer than the author's exposition of the principles and practice of both good and bad ventilation.

The pictorial illustrations are abundant, and, altogether, the work is the most complete and satisfactory of any we have seen devoted to this subject. For sale by Van Nostrand.

Modern Breech-loaders: Sporting and Military. By W. W. Greener. London: Cassell. For sale by Van Nostrand.

Mr. Greener is well known as a successful manufacturer of breech-loading sporting guns, and from the intimate knowledge of the subject possessed by himself and his late father, was well able to write a description of the various weapons known as breech-loading rifles. The book has no preten-

sions to any literary merit, but is a simple statement of the construction and capabilities of the various forms of breech-loaders, so many of which have sprung into life within the last 5 or 6 years. It also contains much useful information on revolvers, while the Gatling gun and the mitrailleuse, together with the various kinds of gunpowder, obtain their share of notice. At a time when we hear so many depreciatory statements of the Martini-Henry rifle, it is satisfactory to read the accounts of its performances which Mr. Greener has collected; and whatever may be invented in the future, we may rest assured that the troops of this country are, or will be, armed with as good a rifle as those of any other nation.—*Mechanics' Magazine.*

Bridges' Gunner's Pocket-book. By Capt. T. W. Bridges, Royal Artillery. London, E. and F. N. Spon. For sale by Van Nostrand.

Nowadays nearly every profession has its special "pocket-book," and why not the artillerist? So thought Capt. Bridges; hence this little book, which originated in a few tablets he was in the habit of carrying in his pouch, and which, amended and enlarged, he has now published in a waistcoat-pocket form, consisting of more than 60 pages of useful information to the gunner, whether volunteer or regular. Here we find rules for finding the distance of hostile batteries, and tables giving the range of guns for various degrees of elevation; the drills for the different service guns, and various other items, from the rations for horses to the trumpet call for the soldiers' mess.—*Mechanics' Magazine.*

MISCELLANEOUS.

The Specific Gravity of Oils and their Co-efficient of Expansion.—The sp. gr of oils as determined by oleometers is liable to inaccuracy from imperfect instruments. I am accustomed, in testing oils, to reject the use of the oleometer, and to determine the sp. gr. by finding the weight of a known volume of the oil, and calculating its sp gr. with reference to water at 15 deg. C. The sp. gr. varies very much with increase of temperature. In order to reduce the found sp. gr. to the sp. gr. at 15 deg., C., it is necessary to know the co-efficient of expansion of oil.

For the determination I use a 50 c.c flask.

It is necessary, first, to very carefully determine the weight of boiled distilled water which the flask contains at 15 deg C. This having been determined, we next find the weight of 50 c.c of the oil under examination, and the temperature at which this is taken. Then, the weight of oil, divided by the weight of water at 15 dg. C, will give the sp. gr. of the oil at the observed temperature.

For example: 50 c.c. of castor-oil at 17.2 deg. C., equalled 47.6487 grammes. This divided by the weight of 50 c.c. of water at 15 deg. C. equalled .9654, that is, .9654 is the sp. gr. of the sample at 17.2 deg C.

The co-efficient of expansion is the difference in sp. gr. which corresponds to a difference in temperature of 1 deg. C.

Suppose the sp. gr. of an oil is determined at 15 deg. C., and is found to be .9162. The sp. gr. of the same oil determined at 20 deg. C. is .9131. The difference, .0031, corresponds to an increase of 5 deg. C.; that is, .000[illegible] for 1 deg. C. In the same way the co-efficient of expansion is determined with sp. gr. taken at different temperatures and the average taken. I have made such determinations, and the following are the average results of a large number of trials:

Temp.		Co-ef. Exp.
14.4 deg. C. to	20 deg. B =	.00064[illegible]
14.4 deg.	25 deg. =	.000641
15.0 deg.	20 deg. =	.000610
15.0 deg.	25 deg. =	.000625
Average,		.000629

or, the co-efficient of expansion is .00063 for 1 deg. C.

The oil selected for this determination was pure virgin olive-oil.

In testing an oil by this method, it is best to make the determination at a temperature as near 15 deg. C. as possible.

We have then this rule: Multiply the difference between 15 deg. C. and x deg. C by .00063, and add or subtract the product to or from the sp. gr. previously obtained, according as the temperature is above or below 15 deg. C.

In the example above quoted, the sp. gr. of castor-oil is found to be .9654 at 17.2 deg. C. To refer this to 15 deg. C. we have: 17.2 deg. — 15 deg. = 2.2 × .00063 = .001386 ∴ .9654 + .0013 = .9667 = the sp. gr. at 15 deg. C.

To clean flasks, test-tubes, etc., which have contained oil, I use the following method: Let the oil drain off well; then put into the flask a little saponified red-oil; or better, melt a little palm-oil therein, and unite it with the oil by turning the flask around. The resulting mixture is very easily saponified by a hot caustic alkali. Every trace of oil can be removed by this treatment, which is far less expensive and troublesome than treatment with ether.

Commercial oils differ very much in sp. gr., although they may be classed under the same name. In the following table I give the results of my tests of the chief commercial oils. With but few exceptions, I procured the samples from first hands, and I believe them to be fair average samples of the oils sold in this city:

Table of Sp. Gr of Oils.

co-ef. of exp. = .00063 for 1 deg. c.

	15 deg. C. 59 deg. F.
Sperm, bleached, winter	.8813
" natural, winter	.8815
Elaine	.9011
Red, saponified	.9016
Palm	.9046
Tallow	.9137
Neatsfoot	.9142
Rapeseed, white, winter	.9144
Olive, light greenish yellow	.9144
Olive, dark green	.9145
Peanut	.9154
Olive, virgin, very light yellow	.9163
Rapeseed, dark yellow	.9168
Olive, virgin, dark clear yellow	.9169
Lard, winter	.9175
Sea-elephant	.9199
Tanners' (cod)	.9205
Cottonseed, raw	.9224
Cottonseed, refined, yellow	.9230

Salad (cottonseed)	.9231
Labrador (cod)	.9237
Poppy	.9245
Seal, natural	.9246
Cocoanut	.9250
Whale, natural, winter	.9254
Whale, bleached, winter	.9258
Cod-liver, pure	.9270
Seal, racked	.9286
Cottonseed, white, winter	.9288
Straits (cod)	.9390
Menhaden, dark	.9292
Linseed, raw	.9299
Bank (cod)	.9320
Menhaden, light	.9325
Porgy	.9332
Linseed, boiled	.9411
Castor, pure cold-pressed	.9667
Rosin, third run	.9887

[*Mechanics Magazine.*

Underground Temperature.—In a paper on this subject, read at the British Association, Prof. J. D. Everett said the intended boring at the bottom of Rosebridge Colliery had not been executed, recent occurrences in a neighboring pit having given the manager reason to fear an irruption of water in the event of such a boring being made. Careful observations of temperature have been taken by the engineers of the Alpine tunnel under Mont Frejus (commonly called the Mont Cenis tunnel). The highest temperature in the rocks excavated was found directly under the crest of the mountain, which is quite a mile overhead. This temperature was 85.1 deg. Fahr.; the mean annual temperature of the crest over it was estimated, from comparison with observed temperatures at both higher and lower levels (San Theodule and Turin), at 27.3 deg. Fahr. Assuming this estimate to be correct, the increase of temperature downwards is at the rate of 1 deg. in 93 ft., which, by applying a conjectural correction for the convexity of the surface, is reduced to about 1 deg. in 81 ft., as the corresponding rate under a level surface. This is about the rate at Dukinfield Colliery, and is much slower than the average rate observed elsewhere. The rocks are extremely uniform, highly metamorphosed, and inclined at a steep angle. They contain silica as a very large ingredient. They are not faulted to any great extent, and are very free from water. It is proposed to sink two bores, to the depth of from 50 to 100 ft. at the summit, and another point of the surface over the tunnel, with the view of removing the uncertainty which at present exists as to the surface temperature. Mr. G. J. Symons has repeated his observations at every fiftieth foot of depth in the water of the Kentish Town well, between the depth of 350 and 1,100 ft., the surface of the water being at the depth of about 210 ft. The observations which have been repeated, are thus completely free from the disturbing effect of seasonal changes.

The results obtained agree closely with those previously found, and show, between these depths, a rate of 1 deg. in 54 ft., which, from the estimated mean temperature of the surface of the ground, appears to be also very approximately the mean rate for the whole 1,100 ft. The soil from 325 to 910 ft. of depth consists mainly of chalk and marl, and shows a mean rate of 1 deg. in 56 ft. From 910 to 1,100 ft. it consists of sandy marl, sand, and clay, and shows a mean increase of 1 deg. in 54 ft. The former of these is in remarkably close agreement with very trustworthy determinations made by Walferden, from observations in the chalk of the Paris basin. These are as follows: Puits de Grenelle, Paris, depth 400 metres, rate 1 deg. Fahr. in 56.9 ft.; well at Military School, Paris, depth 172 metres, rate 1 deg. Fahr. in 56.2 ft.; well at St. André, 50 miles west of Paris, depth 253 metres, rate 1 deg Fahr. in 56.4 ft. General Helmersen, of the Mining College, St. Petersburg, informs the secretary, that in sinking a well to the depth of 540 ft. at Yakoutsk, in Siberia, the soil was found to be frozen probably to a depth of 700 ft. The rate of increase from 100 ft. to 540 ft. was 1 deg. Fahr. in 52 ft. A new pattern of thermometer has recently been constructed for the committee, which promises to be of great service. It is a maximum thermometer, on Negretti's principle, adapted to be used in a vertical position, with the bulb at the top. The contraction in the neck prevents mercury from passing into the stem when the instrument receives moderate concussions. Before taking a reading, the instrument must be gently inclined, so as to allow all the mercury in the stem to run together into one column near the neck. On restoring the thermometer to the erect position, the united column will flow to the other end of the tube (that is, the end furthest from the bulb), and it is from this end that the gradations begin. It is set for a fresh observation by holding it in the inverted position, and tapping it on the palm of the hand. This instrument, like that heretofore used by the committee, is protected against pressure by an outer case of glass, hermetically sealed. —*Mining Journal.*

Testing Boilers.—The telegraph states that Mr. F. B. Stevens, of the Camden and Amboy Railway, who has charge of the ferry boats of that line, commenced on Saturday last a series of experiments before a number of distinguished experts, upon rupturing boilers with hydrostatic pressure. The first experiment was one boiler which had been allowed, on a ferry boat, to carry 40 lbs. of steam. Under the test, it leaked at an old patch at 90 lbs. pressure, started the stay bolts at 100, and at 112 the experiment was discontinued. The second boiler experimented upon was also allowed to carry 40 lbs. Under hydrostatic pressure it gave out at 66. The third boiler, which had been allowed to carry 30 lbs. of steam, broke the brace over the crown sheet at 42 lbs., but without a leak at 60 lbs. Four of the brace rivets broke. The fourth boiler gave way at 75 lbs.; it had been allowed to carry 40 lbs. This concluded the day's experiments. Mr. Stevens intends to continue them, and finally explode the boilers by steam, as they are very little injured by hydrostatic test, and can be easily repaired. By this means, the value of hydrostatic pressure in testing boilers will be decided.—*Am. Railway Times.*

Strength of Building Material.—Experiments are sometimes made in regard to the power of stones of different kinds to resist compression, by cutting 1 cubic in. of each, placing it between 2 steel plates, and charging it with increasing weight till crushed. For convenience' sake, this weight is applied by means of a lever, so as to obviate the necessity of actually handling the hundreds and thousands of pounds—one or more sliding weights on a strong beam being sufficient for these experi-

ments. The results are indicated in the following table, in which the number of pounds is that of which the substance could bear the pressure, while it was crushed by the addition of more:

Table of resistance of a cubic inch of divers building stones against crushing pressure.

Name of Stone.	Where used or wherefore.	Weight applied in pounds
Inferior pale brick	For filling walls	2,000
Common good brick	" partition walls	4,000
Hard brick	" floors	4,500
Pressed Phila. brick	" fronts of houses	5,000
Sandstone from Acquia Creek, strata laid vertical	Many public build'gs, Washington	5,500
Marble, Baltimore (large crystal)	House trimmings, Baltimore	8,000
Sandstone, Acquia Creek (strata laid horizontal)	Public buildings, Washington	8,300
Marble, Montgomery Co., Pa.	House fronts, door sills, etc., Philadelphia	8,900
Marble, Lymington (strata vertical)	National Washington Monument	9,100
Marble, same (strata horizontal)	National Washington Monument	10,100
Marble, Stockbridge	City Hall, New York City	10,400
Sandstone, Seneca	Smithsonian Instit'te, Washington	10,800
Marble, Lymington (large crystal)	National Washington Monument	11,100
Granite, Patapsco		11,200
Marble, Italian	Statuary	12,600
Marble, Baltimore (small crystal)		18,000
Marble, Lymington (small crystal)	Washington Monument	18,200
Marble, Hastings, N. Y.	University Building, New York	19,000
Gneiss, Palisades, near New York	Pavements	19,750
Marble, Lee, Mass.	House fronts, Boston, etc.	22,700
" East Chester	Post-Office, Washington	23,900
Granite, Dry Island, Me.	New Post-Office, N. Y., Extension of Treasury, Washington	24,000

—*Manufacturer and Builder.*

Picking Tools.—Mr. Jackman, of Sheffield, has recently patented an invention the object of which is, by the adoption of suitable mechanical arrangements, to attach in an effectual manner picks axes, adzes, hoes, and other similar tools or instruments, to their handles in such a manner that they may be more readily secured to and detached therefrom than by any arrangements of construction heretofore known or used. A socket of malleable iron or other suitable material is provided for receiving the picking tool or blade; this socket is attached to a wooden handle in the usual manner The picking tool or blade is made with a depression or protuberance which fits into, or upon, a corresponding part of the socket; or, if preferred, there may be a series of depressions or protuberances, so as to give the tool a firmer hold of the socket. The picking tool or blade is secured in the socket by means of a set-screw, the point of which acts upon a "gib," or separate piece, which distributes the pressure of screw over a considerable surface of the tool; the set screw is further secured against slackening by the introduction of one or more lock-nuts. The set-screw, gib, and lock-nuts are conveniently arranged in the shaft side of the tool, thus dispensing with all projections in the end or sides of the pick, which are objectionable. The advantages of this invention are, that the tools may be easily replaced when worn or damaged, that they may be readily and securely fixed in their proper position in the socket, so that the set-screw, being provided with lock-nuts, will not easily work loose; and, especially, that the "gib," or separate piece, will distribute the pressure of the set screw over a considerable surface of the tool, thereby giving greater security against slackening.—*English Mechanic.*

Registering Apparatus for Steam Gauges.—This little apparatus, invented by Mr. Bernard Stangk, of Rouen, will be found to be very useful to every manufacturer using steam power; its object is to register with complete accuracy the variations of the pressure of steam as marked by the gauge. By this instrument the chief of a factory is able to know at any moment the variations in the power developed by the engines, and none of his employees can interfere with the registration. The apparatus is simple and easy of application. It consists of a closed glass box, being in communication with the handle of the gauges by means of a little rod, at the end of which is fixed a small box running freely in a slide, and which is provided with a pencil. Under this pencil there is a drum covered with a paper ruled with 24 horizontal lines, denoting the 24 hours of the day, and with 8 vertical ones corresponding with the divisions of the gauge. The drum is moved by clock work, and as the drum accomplishes its 24 revolutions in 24 hours, the pencil leaves on the paper a true registration of the different pressures of steam which have been indicated by the gauge, marked by lines more or less undulating. The variations of pressure are found by measuring the undulations on the vertical line, and by comparing these with the crossings on the horizontal ones, the time of occurrence is found. The little instrument serves also as a tell-tale as to when the fires were lighted, covered, or put out.

Stone Cement.—Hydrated silica combines much easier with bases than common quartz-sand (anhydrous silica). On this Prof. Boettger has based the employment of infusorial earth, a white pulverulent mass which occurs in various localities in Europe and in this country, in large masses as the binding ingredient of an excellent cement for stone-work. He mixes equal parts of infusorial earth and oxide of lead (litharge) with $\frac{1}{4}$ the quantity of hydrate of calcia (freshly slacked lime) and linseed oil varnish to a homogeneous thick paste, and obtains a mass of extraordinarily great binding power, which after some time assumes the hardness of common sandstone. This cement is applicable in all cases where iron is to be fastened in stone, where artistic stone-work, such as fountains, vases, statuary, etc., is to be mended; in short, where small quantities of the binding material are required. For the more common uses of the mason and stonecutter, this cement is, of course, too dear to permit of extended application.

The relative value of gold and silver in the days of the patriarch Abraham was 1 to 8; at the period B. C. 1000 it was 1 to 12; B. C. 500 it was 1 to 13; at the commencement of the Christian era it was 1 to 9; A. D. 500 it was 1 to 18; A. D 1100 it was 1 to 8; A. D. 1400 it was 1 to 11; A. D. 1613 it was 1 to $15\frac{1}{2}$; which latter ratio, with but slight variation, it has maintained to the present day.

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THE METRIC SYSTEM.*

I.

Gentlemen of the Convocation: The sense of the right of property is an instinctive feeling, of which the existence is co-extensive with intelligence. We find abundant evidence of its presence in the lower animals as well as in ourselves. The dog, for instance, when he has satisfied his hunger, carefully stores up the superfluous bone of to day in prudent provision for the anticipated wants of the morrow. The beast of the forest bears his prey to the lair which he has appropriated to himself, and the birds defend with spirit the nests which their own labors have constructed. In the social animals, as the beaver, and the social insects, as the ant and the bee, we see the principle more broadly developed. In these cases, the dwelling which the common toil has constructed or prepared, and the stores which the common industry has gathered, are the common property of all, and are apportioned for the benefit of individuals upon principles which we probably do not understand. But the lower animals, though they appropriate to themselves articles which seem desirable, and assert a right of property in the objects thus appropriated, never propose to relinquish one possession in consideration of an equivalent offered in the form of another. They have no notion of commerce or exchange even in its simplest form. The commercial idea makes its first appearance in man. It is present in every stage of human civilization. Its earliest practical illustration is in the form of barter, in which objects supposed to have value are exchanged one against the other, or a single one of a certain description for several of another. But as wealth increases, and its forms become more diversified, the necessity of determining equivalents by quantity rather than by tale, becomes manifest; and out of this necessity springs the creation of conventional standards, by means of which quantities may be always and everywhere verified and definite quantities be correctly ascertained. Hence have arisen the various systems of weight and measure which have prevailed among different peoples, some form of which has been found to accompany even the rudest civilization. Such systems, having originated before anything like intellectual culture existed, have been constructed without any thought of scientific method, and have owed their earliest form to accident or caprice. As social and political institutions have become more fully developed, legislation has stepped in from time to time to alter, if not to improve, these primitive systems; to change the value of their unit bases, or to modify the relations to these bases of the derivative denominations; until, at the present time, there is no reason to believe that there survives in any existing system of weights and measures a single value of

* A paper read before the University Convocation of the State of New York. By Frederick A. P. Barnard, D. D., LL. D., President of Columbia College.

any unit identical with one in use two thousand years ago; or a law of derivation connecting the different branches of the system, the weights and the measures of capacity, for instance, with the linear base, such as governed the same relations at a period so far remote in the past as the earlier ages of the Christian era.

To change systems of weight and measure, and to change them by legislation, is therefore no new thing, first thought of in our day. It is a thing which has been going on ever since the birth of civilization. It is not in itself a good thing or a desirable thing, or a thing we should engage in for its own sake; neither is it a desirable thing to pull down a dwelling in which we have long lived, even though it may be inconvenient. Time has, perhaps, reconciled us to the inconveniences; use has made us forgetful of their existence, or habit has possibly, for such is human nature, converted defects into merits in our eyes. But when we do pull down the old home, and we often do, and Americans do so probably oftener than they ought, and in its place erect an edifice constructed on better principles, we find, in the increased comfort which follows, a justification of the proceeding, and an adequate compensation for all the trouble and expense it has cost us.

There has grown up within our own century a branch of systematic inquiry, which in recent years has been prosecuted with a high degree of activity, under the name of social science. This inquiry comprehends in its scope every problem interesting to human society, political, educational, moral, economical, commercial, statistical, and sanitary: its aim being not merely the enlargement of knowledge for its own sake, but the practical amelioration of the condition of man. In an investigation so comprehensive, the subject of weights, measures, and coins, the instruments by means of which the values of all objects which make up the wealth of nations must be measured, and by means of which also the exchanges of commodities which constitute the world's commerce must be effected, could not escape attention. An earnest movement has accordingly been going on in our time, which, during the past twenty years, has been pressed with especial urgency, having for its object to remove the impediments to freedom and facility of commercial intercourse between nations, and the obstacles to the intelligent understanding on the part of individuals, of the material condition of the world and the progress of contemporaneous history, which arise from the diversity and discordance of existing metrological systems. At a former meeting of this convocation, an ardent friend of the movement here spoken of, a gentleman who was at that time a member of our national legislature, addressed you on this subject, and recommended it earnestly to your favorable consideration. The result was disappointing. The movement failed to command from you the anticipated sympathy; and in approaching the same subject to-day, I feel how heavy is the task of one who attempts to plead before you a cause in which so able, so zealous, and so eloquent an advocate has failed.

There is something in the very fact that I venture to address you upon a subject which has occupied the attention of your learned body now for several years, which has been regularly referred to a committee of able and distinguished men selected from your number, which has been maturely considered and elaborately reported on by them, and has, at length, after full opportunity for discussion and comparison of views, been finally disposed of by the adoption and publication of their report, which convicts me, in appearance at least, of presumption, and which is not likely to win me your favor in advance. It is, therefore, due to myself to say, that in asking your indulgence while I recall your attention for a few moments to a subject which has lost its novelty for you, I am acting under instructions from a body whose anthority I am not at liberty to disregard. On the first day of May, last, a resolution was adopted by the board of trustees of Columbia College, in the following words:

"*Resolved*, That the President be requested to attend the next meeting of the Convocation of the University of the State of New York, and to explain to that body how far the views of the Faculty of Columbia College, in respect to the Metric System of Weights and Measures, are in accordance with those set forth in the report of a committee made to the Convocation on that subject in August last."

This resolution imposes upon me a duty which I have no choice but to fulfil. I

trust, therefore, that I shall not be suspected of intending any disrespect to the Convocation if, in discharging it, I give expression to views considerably at variance with those which have received the sanction of this body.

The interest of the trustees of Columbia College in the Metric System of Weights and Measures, dates back to a period preceding my own connection with that institution. In the minutes of the Faculty of the college, I find it stated, under date of April 8, 1864, that a resolution calling the attention of the Faculty to the subject, had been passed by the trustees on the Monday preceding; and this resolution is recorded under a date a little later, in the following words, viz.:

"*Resolved*, That in view of the important international movement in progress for the purpose of establishing a uniform system of Weights, Measures, and Coins for the civilized world, it be referred to the Faculty of the College to prepare and submit to this board a memorial to the Congress of the United States, on behalf of the college, expressing its sense on the importance of the measure in question."

In compliance with the request of this resolution, a committee was appointed to draw up such a memorial, consisting of Professors McVickar, Anthon, Davies, Lieber, and Rood. Upon the 13th of May next following this appointment, the committee reported a memorial which was adopted by the board of the college, and ordered to be signed by the president and laid before the trustees.

In this memorial, the metric unit of length is compared with the British (and American) unit; and the metric system of derivation, by which the measures of surface, capacity, solidity and weight, are deduced from the unit of length, is compared with the confused system, or lack of system, which unfortunately pervades the metrology of the English-speaking nations; and on both these points the opinion of the Faculty of Columbia College is expressed, with an emphasis which argues deep conviction in favor of the former. The memorial goes further, and advocates certain views in regard to the unification of the coinage of the world, in which I should not be able fully to concur, but to which I design to give no present attention, since the coinage question is one which will probably be independently settled; though, when it is settled, it will doubtless be settled by making the weights of all coins metrical.

In the minutes of the trustees of the college, I find it recorded that the document here spoken of was read before that body on the 18th of May, 1864, and that an order was afterwards taken, directing that it should be forwarded to the Speaker of the House of Representatives at Washington, with a request that he should lay it before the national legislature. This memorial is spread at length upon the minutes, both of the faculty and of the trustees. Along with it appears, in the latter, an independent memorial, expressing similar sentiments, which was adopted by the trustees in their own behalf, and forwarded to Congress, by their order, at the same time.

With all this history I had nothing to do. The whole transaction had been completed before I became a member either of the Faculty or of the Board of Trustees of Columbia College. I have recounted the particulars in evidence that Columbia College had taken her position on this question long ago. The duty imposed upon me is to state to you some of the reasons which have led her to assume this attitude.

And here I wish to be understood as not intending to assert that, among the members of the two bodies whom I, in a certain sense, represent here, there are not individuals who dissent from the views to which the majority have committed themselves. Among the trustees, indeed I know of none such; but your own records show that there is at least one distinguished dissentient among the Faculty. If there are others, they, as well as myself, are members of this convocation; and they may, and perhaps will speak for themselves. I am not aware that there are any, but my impression may be mistaken.

To proceed now to the matter in hand, it is, in the first place, a fact particularly noteworthy that the trustees of Columbia College, in their resolution of April, 1864, did not mention the metric system in so many words, nor propose to memorialize Congress in favor of any particular system of weights and measures designated by name. What they asked was, that the college should express its sense of the importance of the creation of a *uniform*

system of weights and measures for the use of the civilized world. If they have been led to believe, as I think they have, that such a uniform system can be reached in no other way than through the ultimate adoption of the metric system; and that whatever may be the differences of opinion as to this matter just here and now, such a result most inevitably will be reached in this way sooner or later, it is impossible that they can regard without concern the exertion of any influence which may serve sensibly to retard an event deemed by them so desirable, and which, however retarded, is, in their opinion, sure to come at last.

But still the question raised by them, and the question first in order before us now, is not, whether it is expedient that we should forthwith adopt the metric system; it is rather, whether it is worth while to try to secure a common system; because if this is not so, there is nothing left to talk about. Nor yet, supposing that this first question is settled affirmatively, and we agree that a common system of weights and measures would be worth having if we could get it, can we make the question of the metric system even the second question in order; for the second question should be, what are the efforts, of those which we are able and willing to make to secure the desired object, in attempting which we may be encouraged by the hope of success; and what are those which we may as well take warning in the outset to avoid, as certain inevitably to fail.

Now, in looking at the different metrological systems at present in use in the civilized world—and the number is very encouragingly smaller at present than it was even 20 years ago—we shall see that the great obstacle in the way of the practical unification of systems is not the mere fact of difference in the absolute magnitude of the standard units, whether of weight or of length or of surface or of capacity; nor the mere fact of difference in the names by which we distinguish these units and their multiples or subdivisions; nor the mere fact of difference in the arithmetical law by which the several denominations of weight or measure are related to each other; nor yet the greater or less degree of exactness with which the base of any system may conform to any dimension in nature, variable or invariable; though these are matters concerning which a great deal of breath is wasted in the discussions which go on about the metric system; the difficulty which stands out so prominently as to dwarf the rest to insignificance, is the fact that the standard units of these several systems are practically incommensurable—I say *practically* incommensurable, I am not using the term with strict scientific severity; but the difficulty is as serious as if the incommensurability were actual and absolute.

To illustrate what I mean, the Austrian foot measure, for instance, exceeds our own by 361 ten-thousandth parts; or, expressed in inches, is equal to 12 British or American inches and 4332.10000 of an inch. We might reverse the mode of presentation, and say that the American foot is 0.96516 of an Austrian foot, or 11.5819 Austrian inches. The fractions here given do not express the exact relation. We may run the decimals on for half a mile without reaching the end; but they go far enough for the purpose of my illustration.

To transform, therefore, a value expressed in one of these measures, into an equivalent value expressed in the other, is an operation laborious and irksome. But the arithmetical disadvantage is by no means the whole, or even the greater part of the evil which this state of things produces. A much more grave consideration is the fact that it interposes an effectual bar to the intelligent interchange of thought. It renders it impossible for an American to converse understandingly with an Austrian on any subject involving quantities of any description. It makes it impossible for an American to derive instruction from an Austrian book or magazine or journal where quantities are mentioned, or an Austrian from an American. This is an enormous evil, and as it exists not in this quarter only, but everywhere, the world has crying need of its removal. It is the evil of which, first and chiefest of all, the advocates of metrological reform desire to be rid. And yet unless I greatly misunderstand the purport of much of the reasoning I hear going on upon this subject, the very fact that this abominable evil exists, the very fact that there is something to be got rid of, and something that we want to be rid of, and something which we ought to be rid of, is

made an argument why we should not try to be rid of it at all. If there are any to whom this argument is satisfactory, with them, of course, the case is closed, and upon such, nothing that I can say will produce any impression. There are some, probably, not of this class, and they may be disposed to consider with me what means there are by which we may be relieved of this artificial obstruction to intelligent communication with other peoples. Three methods present themselves. Continuing the illustration furnished by the example just presented, they are these: We may adopt the Austrian unit; Austria may adopt ours; or both nations may adopt a third, incommensurable with either. Any one of these expedients will reconcile us with each other; that one will be chosen, if any, which, besides doing this, will do most to promote the grander object of an universal accord among nations.

Now, if we go over to Austria in this matter, we lose more than we gain; and in speaking of loss and gain here, I mean loss and gain as it respects our international relations, and not as it respects our internal or domestic affairs—(I am setting aside altogether, therefore, that inconvenience to ourselves at home, which would exist temporarily in consequence of the incommensurability of the new unit with the old—an inconvenience on which your able reporter has so feelingly dwelt as likely to result from our giving up the foot for the metre)—we lose then, I say, more than we gain by this concession, because we fall out of harmony with the great British Empire for the sake of securing harmony with a people who occupy, as Mr. Webster more forcibly than politely remarked, only a small patch of the earth's surface, compared with our vast domain. On the other hand, if Austria yields the point, she will fall into harmony, it is true, with us and with Great Britain—nations, however, with whom which she is geographically separated very widely; but this advantage will be gained at the expense of discord with the several peoples who lie between her and the British Islands; all of whom have embraced the metric system, or adopted metric values in their own. If, however, thirdly, both of us adopt the metre, America will not only be in accord with Austria but with the greater part of continental Europe at the same time; and as Great Britain has given decisive indications of a disposition to become metric also, the probability is that soon the whole civilized world, unless Russia and the Scandinavian people continue to be exceptions, will have but a single system of weights and measures.

Now if this difference between us and Austria had not been *such* a difference; if the unit, for instance, of Austria had been we will say a cubit, and such a cubit (for there have been many of them) as to be exactly equal to 18 British in., the evil of incommensurability would not exist and the question of unification would simplify itself materially. We might both of us agree to adopt a measure of 6 in. as our common unit, and this we might call a span, abandoning both the cubit and the foot. There would be some no doubt who would lament over the loss of the "short and sharp Saxon word, foot," and would find no sufficient comfort even in "span," which, though Saxon and short, is not so sharp; but I think that if a change of this simple description, affecting only names and modes of division, and not actual values at all, would bring us into harmony with any great people, and still more if it would bring us into harmony with all the world, we should do it notwithstanding. This illustrates the immense difference as it respects facility of solution which the problem of metrological unification would present, if the unit bases of the existing national systems were commensurable, as compared with what it is now.

With the great empire of Russia, we have, indeed, precisely such a point of contact in our two national systems of length measure as that which I have just been imagining. It is matter of familiar history, that in the year 1698 the singularly enterprising and energetic Emperor, Peter the Great, passed, incognito, in the train of one of his own embassies, first into Holland, where he engaged himself as an operative ship-carpenter, and labored for months with remarkable assiduity; and secondly, in the following year, into England, where he became finally, master of that important branch of constructive art; and where subsequently having made himself known to the then reigning king, William III., he received from him every honor due to his exalted station. Returning to his own country, he took with him a number of British ship-builders and other artificers, whom he paid with liber-

ality and employed in the navy-yards which he immediately proceeded to found. It was probably a consequence of his own industrial education in England, and of the British predilections of the advisers and practical assistants whom he took home with him to carry out his plans, that he was induced to modify the length of the *sagene*, the standard length unit of the empire, so as to make it commensurable with the British foot. Since early in the 18th century, therefore, the length of the legal standard unit of Russia has been 7 ft., subdivided into 3 archines of 28 in. each; the archine being the unit of common life, just as in England, the yard is the legal, and the foot the practical standard. This state of things admitted of the introduction between ourselves and Russia of a common unit of 4 in. in length, which would have been just the seventh part of an archine and the third part of a foot. But within the last forty years a simpler solution has been found, the Russian government having introduced a subsidiary unit, having the length of $\frac{1}{7}$ of a sagene, and which is called by a name approaching as nearly to the English word foot as the vocal organs of the pecple will allow.

It is unfortunate that a reform so well begun was prosecuted no further. This is the only particular in which the Russian metrological system has anything in common with ours, or with any other existing. And, from a careful examination of all the systems of weights and measures established by law, and at present in use among civilized peoples, I have been unable, except in this single instance, to discover between any two of them any feature of commensurability, whether as it respects weights or measures of length or surface or volume, which has not been introduced by legislation since this century began. Such legislation, however, has done so much toward removing this chief of all obstacles to the attainment of a common system, as to greatly encourage the friends of metrological reform in the hope of an ultimate and complete attainment of the object in which they are so deeply interested. It is worth remarking, furthermore, that every such change has thus far consisted in replacing the values of the weights and measures in common use by other values adopted from the metric system. I will enumerate further on the most important of these changes; pausing here only to present a single example to show how, in some instances, the great evil of incommensurability has been got rid of without the adoption of the metric system in all its details.

In the republic of Switzerland, previously to the year 1851, there prevailed a considerable diversity of systems of weight and measure in the different cantons. The most important may be said to have been those of Berne, Zurich, Basel and Lucerne—I will confine myself to the two first named. In Berne, the fuss (unit of length) was 11.546 in.; in Zurich, it was 11.812 in. In Berne, the pfund (unit of weight) was 18.642 oz. avoirdupois ; in Zurich, it was18.347 oz. In Berne, the maas (measure of liquid capacity) was 1.776 quarts ; in Zurich it was 1.918 quarts. The measures of dry capacity were very various, but those which are most easily comparable were the mass, in Berne, which was 0.3876 of a bushel, equal to 1.550 pecks ; and the viertel in Zurich, which was 0.5826 of a bushel, or 2.330 pecks. Zurich had, in fact, four different viertels for different substances ; the measure given above was for wheat. By a law passed the 23d of March, 1851, it was decreed that, after the 31st of December, 1856, the legal unit of length throughout the republic should be the pied (foot), having the length of exactly 30 centimetres, and that (abandoning the old duodecimal subdivision) this should be decimally divided to tenths, hundredths and thousandths. Multiples of the unit allowed were the brache, 2 ft.; the aune, 4 ft.; the toise, 6 ft.; the perche, 10 ft., and the lieue, 16,000. For the pfund was substituted the livre of 500 grammes, and for subdivision it was left optional to use the binary system of $\frac{1}{2}$ lb. and $\frac{1}{4}$ lb., and so on, or to employ the decimal. For dry capacity, the measure established was the quarteron, equal to 15 litres ; and for liquid capacity, the pot, equal to $1\frac{1}{2}$ litres. For the last fifteen years, therefore, the weights and measures of Switzerland have been commensurable with those of the neighbors with whom she is in most frequent intercourse, and who have all of them more or less completely adopted the metric system.

But though the incommensurability of the unit bases is the principal source of difficulty in effecting the transformations of value from one metrological system to another, the law of derivation of the other

denominations from these bases is not a matter of indifference as it respects this operation. This again can be illustrated by an example which the commensurability of the Russian standard unit of length with our own enables us to derive from the itinerary measure in common use in the Russian Empire. The itinerary unit is the viesta, Anglicized verst, which is equal to 500 sagenes. Now, there is no difficulty in converting versts into British feet, since, the sagene containing 7 ft., 500 sagenes are 3,500 British ft., or the half of 7,000 British ft.; so that we only have to multiply the versts by 7, annex 3 zeros, and take half the result. But if we wish to transform a distance expressed in versts into miles—a mile being the unit of our own itinerary measure—the process is not so simple. There are 5,280 ft. in a mile, and if, in order to avoid this troublesome divisor, we attempt a reduction through the intermediate denominations, we encounter such relations as $5\frac{1}{2}$ yards, or $16\frac{1}{2}$ ft., making a rod, which are more troublesome still. Now if, instead of the present totally indefensible series of relations between our higher and lower denominations of length, we had something a little more sensible, or if not sensible, at least not worse than the Russian—for the Russian, with its ratio of 7 to 1, is only a little less bad than ours—the problem before us would admit of a solution comparatively simple. Suppose, for example, that a mile were made, as it might be, without harm to anybody, a round 5,000 ft. It is true that "the old familiar mile of 1,760 paces," which your reporter seems to cherish so fondly, "would be gone ; and," as he correctly remarks, "the distance from Albany to New York—145 miles—would be known to us" as something quite different, say something like 153 sensible miles. In this case the verst would be 3,500-5,000, or $\frac{7}{10}$ of a mile, and the transformation would be effected by the use of a very small number of figures. It would not, perhaps be worth while to adopt the new value of the mile here suggested, for the sake of being able merely to convert miles to versts, or versts to miles—a thing we have to do too seldom to make it a matter of much interest to us; but it would be quite worth while to make it for the sake of facilitating the thousand other calculations which we are continually called upon to make, involving reductions between the higher denominations of length and the lower. Whether we ever adopt a new linear base for our metrological system or not, every consideration, both of logic and of convenience, demands that we should reform the absurd numerical relations in which our different denominations, especially of length, surface, and capacity, stand to each other. Mention has been made of the mile, the rod, the yard, and the foot. Along with these we may take also the chain of 66 ft., divided into links of which each one is $7\frac{92}{100}$ in., while itself is the eightieth part of a mile. As to surface, our sq. yard is 9 sq.ft.; our sq. rod is $30\frac{1}{4}$ sq. yards, or $272\frac{1}{4}$ sq. ft.; and the acre, our agrarian unit is 160 sq. rods, or 4,840 sq. yards, or 43,560 sq. ft. It would be difficult for human ingenuity to contrive anything more inconvenient or less rational than this. As to capacity, whether liquid or dry, though the relations of the several denominations to each other are tolerably simple, yet their relations to the standard of length, which is, or ought to be, the fundamental base of the system, are as abnormal as it is possible to make them. Our gallon is 231 cubic in., 0.13368 of a cubic ft. ; and our bushel is 2,150.42 cubic in., 1.244456 cubic ft. And our unit of weight has no relation whatever expressible in simple numbers, which the mind can grasp, to our measures of capacity or of length ; for while it is customary to say that a cubic foot of water weighs 1,000 ounces, the relation established 40 years ago by our bureau of weights and measures under authority of law, makes the gallon measure of distilled water at the temperature of 39.8 deg. F., and at 30 in. of the barometer, to weigh 58,372.1754 grains, or 8.3389 commercial or avoirdupois lbs. ; and requires also that the standard or Winchester bushel of 2,150.42 cubic in. shall hold, under the same circumstances, 543,391.89 grains, or 77.6274 avoirdupois lbs. ; from either or both which determinations it appears that the weight of a cubic foot of water, at maximum density, is only 998.0667 oz., instead of 1,000 oz. ; while, if we take the water at the ordinary temperature of the atmosphere, say 62 deg. F., as prescribed by the British statute on the subject, the cubic foot weighs but 997.172 oz. Here are irregularities and imperfections, to the correction of

which it would be well if we would address ourselves, in our own immediate interest and that of our people at home merely, and without reference to our relations with other peoples. Exact calculations, for instance, in which weights are to be deduced from volumes or volumes from weights, are effected under our system only at the expense of much weary labor, of which the necessity is artificially laid upon us by this tyranny to which we are born. For rude calculations we call, indeed, the cubic foot of standard water 1,000 oz., or $62\frac{1}{2}$ lbs.; but for any delicate determination, we must take the cubic foot at 436,654 2 grains, and the cubic inch at 252.6934 grains, numbers which, at whatever inconvenience, the man of science finds himself continually obliged to employ in multiplication and division, to the great waste of his time and expense of his strength.

Now, before directly considering the special question whether the metric system of weights and measures ought to be adopted in this country, it is proper to consider, and it seems to me a duty to consider whether it is possible for us to contribute anything to the important object of bringing the bases of the metrological systems of the world into relations of commensurability. If these bases can be made commensurable, we shall have accomplished something almost as important as to have established absolute identity; and, indeed, under these circumstances, identity, it may easily be believed, will not be slow to follow. Who can doubt, for instance, that Switzerland, having adopted values for her units which are in extremely simple relations to the metric units, will sooner or later adopt the metric units themselves. It is what all the States of North Germany recently resolved to do after an experience very similar. These several States had all, previously to the formation of the Zollverein, their independent systems of weights and measures. When that treaty was entered into, the importance of a common system for custom-house purposes was promptly perceived; and hence a Zollverein pound was adopted, having the weight of 500 grammes. Several of these States, among them Prussia, Baden, Hesse-Darmstadt and Wurtemberg, found it expedient at a later period to adopt this weight for their domestic as well as for their external commerce. And after the Austro-Prussian war of 1866, and the formation of a closer union between the States north of the Maine under the name of the North German Confederation, the desirability of a common metrological system for all the members of the Confederation seemed so great, that a law was finally passed by the Reichstag which was publicly proclaimed by the king in August, 1868, by which the metric system is adopted in full, and made the legal system for North Germany from and after January 1, 1872. As the States of Southern Germany were no less advanced than those of Northern, in the measures they had taken previously to their absorption into the empire, for the assimilation of their weights and measures to those of the metric system, there can be no doubt that the law of 1868, just mentioned, will be extended over them also. Thus it appears that when different metrological systems approach each other so far as to become commensurable in their fundamental units, there is a drift towards identity which becomes at length irresistible.

Are we willing to do anything to bring our own system into relations of commensurability with those of the rest of the world? If so, the question second in order comes up, what efforts are there in our power to make, which are likely to advance the object, and what are likely to be fruitless? It may be well to state, in the very outset, so as to bring the really vital question directly before us, that except the metric system and that which we use ourselves, no other existing, and no other likely to exist, can be advocated as having the least claim to become the system of the world. One of these, therefore, must sooner or later prevail; for no man not totally regardless of the history of the past, and not absolutely blind to what is taking place under his own eyes in the present, can possibly pretend to believe that the world is to be for ever without a uniform system of weights and measures. At the universal exposition of 1867, in Paris, 13 measures of length from different countries were exhibited under the name of foot, or its equivalent; but among these there were only 8 values essentially different, and 2 of these were metric. Yet after giving some attention to this subject without pretending to ex-

haust it, I have found more than 100 foot measures, each differing more or less from all the rest in value, which have been in use at one time or another at one part or another of Europe. Similar remarks might be made of the units of weight and capacity. There has, therefore, been large progress made toward uniformity, and the most important steps and the most significant steps are those which have been taken within our own century. We cannot suppose that this progress is going to be arrested at the point which it has now reached. Of the two systems therefore just now indicated as the systems between which the world must choose, unless in regard to this matter it shall henceforth stand still for ever, one or the other must sooner or later prevail. Which shall it be? Which is it likely to be?

At the close of the last century the metric system was thrust upon France, under circumstances of disadvantage and with an imperfect success, which Mr. Adams has very eloquently described in his able report of 1821, which you have caused to be reprinted. Though the commission by which the system was matured was as far international as it was possible in the then existing political and military condition of Europe to make it, representatives being present not only from France but also from the Netherlands, Denmark, Sweden, Spain, Switzerland, Sardinia, Rome and other Italian States, yet no government except the French spontaneously adopted and endeavored to apply in practice, the results of their labors. The conquests of the first empire carried the system forcibly into the low countries, into Westphalia, into Italy and into the Iberian peninsula; but the difficulties which it met with there were in general greater than at home; not only because the manner of its introduction did violence to men's established habits of thought, but because its existence was a badge of subjugation and a perpetual reminder of the national humiliation of those who were compelled to use it. These all with one accord, therefore, took advantage of the downfall of the empire, to throw it promptly off. Nor even in France, presented as it was to the people without any adequate education as to its characteristic features, or any sufficient allowance of time to permit them to become familiar with its details, was it established without a struggle against inveterate habits and rooted prejudices continued through more than a quarter of a century. Long before the termination of this struggle, however, the aversion to the system in the countries foreign to France, to which it had been carried during the empire, began sensibly to subside ; and in the Netherlands, whose intimate relations with France had caused it there to take a deeper root than elsewhere, it was actually re-established as early as 1817. It was re-established, that is to say, in all particulars except the nomenclature ; but while the metric units and the metric decimal relations were adopted, the ancient names of weights and measures were retained. But Belgium, since the separation, has adopted the nomenclature also; the old names are still preserved in Holland. The condition of things therefore, at the time when Mr. Adams wrote, may be thus described. A quarter of a century had passed, and yet the system was not yet firmly established in its own home ; it had been rejected generally by the neighboring peoples who had tried it, and its chances of success in the eyes of the disinterested spectators of the experiment appeared, as may be gathered from Mr. Adams's own report, to be as nearly as possible at zero. Since that period just one-half a century has passed, and the aspect of things is bravely changed. One third part only of this period sufficed for the subsidence of all the imputed disaffection of France, and in the Netherlands, as we have seen, this disaffection, if it was ever strong, died out much earlier. From the year 1837 onward, the people of those two countries have not only been reconciled to the system, but warmly attached to it. The neighboring peoples upon whom it had been early imposed by force, and who had indignantly thrown it off, have all voluntarily re-adopted it. That early attempt to coerce them into its acceptance, while it roused every instinct of their natures to resistance, had at least the effect to educate them to a knowledge of what it was. And the acquaintance which they thus formed of its merits, produced, when passion had subsided, its natural result in the re-establishment of the system by their own free choice. From information obtained at the uni-

versal exposition of 1867, where a special pavilion was set apart for the display of the standards of weight, measure, and money of all nations, officially authenticated, I am able to state some particulars as to the progress of this great movement toward metrological uniformity. First in the order of time after France, Holland and Belgium, came the Italian States, which, beginning with Sardinia, by laws initiated in 1845, and carried into execution in the following year, made the metric system the only legal system of weights and measures in that peninsula. Not far from this time was formed the custom union, or zollverein which I have already mentioned, among the German States, including Prussia, Hanover, Saxony, Bavaria, Baden, Wurtemberg, the Hessian Duchies, and several smaller principalities and free cities. This was established for the purpose of doing away with the serious obstruction to commerce interposed by the existence of numerous and neighboring custom-house frontiers ; but in order that it might not create as much trouble as it removed, it adopted, as I have mentioned already, a common system of weights and measures, giving metrical values to the units. The metric pound adopted was half a kilogramme, or 500 grammes ; and this was found so convenient that it subsequently became the national as well as the international pound in several of the principal States and many of the smaller ; as, for instance, in Prussia, Wurtemberg, Baden and the Hesse Darmstadt.

In some, as in Baden and Hesse-Darmstadt, metrical values were also given to the unit of length, which was still called the *fuss*, though the old *fuss* was abolished, and the duodecimal subdivision was at the same time abandoned. Others of these States, which still retained the values of the fuss to which they were accustomed, perceiving the great superiority, in respect to convenience, of the decimal over the duodecimal ratio, also abolished the inch and divided the foot into tenths and hundredths. Among these may be named Bavaria, Prussia and Wurtemberg. Very shortly after the revolutionary excitements of 1848, the empire of Austria, by treaty with Prussia, became connected with the Zollverein, and introduced the metrical weights and measures of that union into all the custom-houses of her extended frontier ; nor has the course of events, military or polical, of recent years, produced in that empire any change in this respect. The action of the North German confederation, by which the metric system in full became the system of all the Northern States, for domestic as well as for external uses, took place in 1868, as has been already mentioned. In the meantime, other States not connected with the Zollverein, began to fall in with the drift now becoming so general. In 1841 took place the legislation in Switzerland above described, which gave to that confederation a metric system of weights and measures after 1856.

In 1852, Denmark adopted the metric pound of 500 grammes, decimally divided. In 1855, Sweden, without changing the values of her standard units, introduced partially the principle of decimal derivation for the inferior and superior denominations, and this by a later enactment of 1865, she has extended through her whole system. In Spain and her colonies, the metric system was established by law in 1859, the names of the units having been partially transformed to bring them into harmony with the language, the metre being called the metro, the litre the litro, etc. In 1864, the metric system was established in Portugal, and at a period which I cannot exactly state, it was adopted by the Kingdom of Greece. Even Turkey has recently made a beginning toward bringing her system into harmony with that which is now so rapidly becoming the system of all continental Europe, by giving to her unit of length, the archine, the value of 75 centimetres, or three-quarters of a metre. In Great Britain, by an act of Parliament passed in 1864, the metric system is legalized, though it has not been made compulsory. In 1864, another act making the metric the exclusive system for Great Britain, passed its second reading in the House of Commons, having thus reached a stage of legislation where the final passage of a bill is commonly regarded as assured, when it was withdrawn by its originators, as yet premature ; but the fact of this remarkable success is a signal evidence of the state of opinion among the enlightened classes of the British people, and a plain premonition of what Great Britain will sooner or later do. In our own

country the use of the metric system in business transactions was legalized by act of Congress of July 26, 1866. The same act provided that postages should be charged in accordance with a scale of metric weights; a letter weighing 15 grammes or less to be chargeable with but one rate of postage. This provision of law, which was practically in favor of the people who use the post-office to a sensible degree, 15 grammes, exceeding the previous local postage weight by nearly 13 grains, or about 1-17th, was, as I am informed, by the effect of a statute passed the following day, quite unintentionally repealed. This second act was designed to regulate postage with foreign countries and it provided that, for postal purposes, ½ oz. avoirdupois should be "deemed and taken to be the equivalent of 15 grammes." The department has applied this provision to the act of the preceding day; so that we have Congress going through with the solemn farce of enacting that the limiting weight of a single letter shall be 15 grammes, but then that these 15 grammes shall be deemed and taken to be only ½ oz.

Undoubtedly the stationery on which these provisions of law were written must be deemed and taken to be a dead loss to the nation. But could anything more forcibly illustrate the liability to error and confusion arising out of diversity of systems of weight and measure, than this example, wherein we see even our highest legislative body when entangled in the maze, incapable of making laws to express its own intentions.

In South America, the metric system has been adopted by Brazil (to take full effect in 1873), in the Argentine Republic, in Uruguay, in Chili and in New Granada. In North America, it is established by law in Mexico. According to the best authorities I have been able to find, the total population of Europe approaches 260,000,000, of whom about 135,000,000 have already accepted the metric system in all its details, or have given to all the standard units of their own systems metric values. Add to these 25,000,000 more in Mexico and South America, and we have a total of 160,000,000 of civilized people in Christian lands who are irrevocably committed to the metric system; while a considerable proportion of the rest have made progress toward this system by adopting metric values in part, like Denmark, and Austria, and Turkey, or by adopting the decimal law of derivation without as yet the metric values, like Sweden; and 70,000,000 more, the people of the British Islands and the United States, have made the use of the denominations of the system lawful in all business transactions within their territory. All this has been accomplished by the pressure of public opinion; it has been distinctively a movement of the people and not of governments; it is a social rather than a political phenomenon. When the metric system was first introduced into France, the pressure came from above, and was resisted by those upon whom it pressed. The people did not understand the system and they did not want it. In the discussions which we hear going on about us concerning it at the present time, the opponents of the system seem constantly to assume that the same plan is to be pursued to-day; and that there exists somewhere an insidious design to force the system upon peoples whether they like it or not. That, I take it, is not the spirit of the modern propaganda. Neither the British people nor the American people are expected to accept this system unless they think it best; but the presumption of some of us is that they will sooner or later think it best.

But why, it may with justice be inquired, are our people so far behind those of the continent of Europe in appreciating the value of the metric system? This is to be accounted for by the same reasons which make them comparatively indifferent to the existence of *any* international system of weights and measures. In a large country like ours, widely separated from the rest of the world, the inconvenience of metrological diversity is immediately and personally felt by the individual citizen only on rare occasions; when, for example, he travels in a foreign country, or when in his own he meets a foreigner raw to our institutions, or when he attempts to obtain some exact information, from the publications of other countries; while the disadvantages to which it daily subjects him operate in a manner so indirect, and are mixed up too with so many other matters, that he fails to connect them with their causes. We can easily understand the state of things which would exist, if we had no public standard of weights and

measures at all; and if every tradesman made his own system and sold his customer, say, so much for so much. This plan is illustrated in Diedrich Knickerbocker's account of the dealings of the early settlers of the Nieuw Nederlandts with the Indians—"every Dutchman's hand weighed a pound, and every Dutchman's foot weighed two pounds." The inconvenience and uncertainty of trade would be only a little less, if, instead of having as many systems as there are tradesmen, we should have as many as there are villages. If, for instance, while a man can get on very comfortably among his immediate neighbors, he finds himself, on driving four or five miles, entirely at sea on the subject of quantities, he will be scarcely able to prosecute any business of magnitude without an amount of trouble and confusion quite intolerable. Enlarge the communities within which common systems prevail, and separate them more widely from those which employ different systems, and the evils which, in the original supposition, embarrassed individuals, now affect the transactions which take place between these communities. Operations are larger, and they are mainly conducted by a particular class; but the misapprehensions, the delays, and the increased expense attendant on these operations are charged, like the customs duties, upon the whole community, without their being clearly conscious of the fact. Our custom houses, and our great importing houses, are compelled, by the diversity of weights, measures and moneys with which they have to deal, to employ an immense staff of computers, whose sole business is to effect transformations of values upon the invoices of the commodities which pass through their hands; and the salaries of all these employés are undoubtedly paid by the consumers of the commodities.

Now, on the continent of Europe, where, in the central part at least, the territories of independent States have heretofore been small, while the population is dense, the evil of a multiplicity of systems of weight and measure, and of custom-house lines occurring every 10, 20, or 30 miles, has been felt as, of course, we can never feel it; and, therefore, there is nothing surprising in the fact, that the people of those States have perceived the need of a common system to be pressing, when we were not thinking of the matter at all. Nor is it any more surprising that, in looking about for a common system, and finding the metric system to be an existing system, and a good system, and, above all, an available system, and the only one apparently available for the purpose, they should have seized upon it and legalized it, and made it permanent, without too anxiously concerning themselves with the questions whether the metre would not have been better if it had been a little longer or a little shorter, or if it had represented something different from what it does represent, or whether, in fact, it does, after all, really represent anything at all.

Considering, therefore, the nature of the causes which have induced 135,000,000 of the people of Europe to adopt the metric system; and considering, furthermore, that in Denmark, Sweden, Austria and Turkey we have 55,000,000 more who have shown by their legislation their appreciation of the merits of this system, or of the principles on which it is founded, it may, I think, be safely said, that the universal extension of this system over the continent of Europe is only a question of time.

Besides the causes which I have mentioned out of which the important changes I have just described have grown, it is to be remembered that there are other influences of a very powerful description actively at work to recommend the metric system to the favorable consideration of the peoples which have not yet received it. The principal of these peoples are the English-speaking nations, and the inhabitants of the Russian Empire. Now for a very long period it has been true that the great body of the scientific men of our own country, of Great Britain and of Russia, have been thoroughly impressed with the value of the metric system; and many of them have been constantly in the habit of using it. That there has been here and there a dissenter may be admitted. Here as elsewhere, *exceptio probat regulam.* But a dissenter who, like Sir John Herschel, holds that the system is good, but that the base ought to have been a ten-millionth part of something else, rather than of a quadrant of the meridian, is not much of a dissenter after all; and one who, like Capt. Piazzi Smyth, bases his metrological theories on religious grounds, and prefers the

pyramid inch as his standard, as a matter of conscience, is not likely to concentrate around him a very powerful party of opposition.

Scientific associations in the countries just named have memorialized their Governments in favor of the metric system. The British Association for the Advancement of Science has done this repeatedly, and the Imperial Academy of Sciences of St. Petersburg has done it likewise. In the year 1866, the National Academy of Sciences of the United States, on the report of a committee with Prof. Henry of the Smithsonian Institute at its head, a committee which had had for two years the subject in its charge, addressed a memorial to the Congress of the United States expressing the sense of the Academy as to the importance of establishing an international system of weights and measures, and recommending the metric system as the best existing.

The scientific journals throughout the world give evidence of the growing practice of scientific investigators of using metric values in their experiments, in their calculations, and in their writings. This began in Germany very early. I find it to be true of Poggendorff's Annalen so long ago as the year 1800. At the present time, it is next to impossible to find any other system of weights and measures but the metric, so much as occasionally named in any of the publications devoted to physics and chemistry in all Germany. Almost the same thing is true of the scientific periodicals of Russia, of Austria, of Denmark, and of Sweden. I have very recently looked through the principal journals of this class, published in the countries just named, and what I assert of them, I assert from personal knowledge. Men of science have adopted this system, not only because of their approval of its principles, but because it is a labor-saving machine of immense capabilities. If you look into our own scientific journals and those of Great Britain, you will find that what has just been remarked of the journals of the Continent is true to a considerable extent of them also, and to an extent constantly increasing. Our analytic chemists use the metric system altogether; and with our physicists its use is becoming every day more general. With the science of the world on its side, therefore, the metric system has a powerful ally, which, added to the influence of the material interests enlisted in its favor, must make its final triumph inevitable.

It will be understood that the scientific associations, and the scientific men to whom reference is here made, are those who deal with the exact sciences, or employ themselves with material nature. Truth is the object of their search—with the uses of the truth discovered, or its relations to the human race, they do not concern themselves. There is, however, another class of inquirers, one to which I have earlier referred, whose influence on the question before us is destined to be powerfully felt, who have created in these modern times a new science of their own, taking as their subject precisely what the former class omits—the relations of truth to humanity. In the scope of their inquiries, they are most widely comprehensive, embracing equally all truth—the moral and the psychological no less than the physical. They call their science social science; it might be called the philosophy of philanthropy, for its object is to discover and remove the causes of human wretchedness, whether they be material, political, mental or moral, and to place the human race in circumstances where it may work out for itself a destiny the noblest of which it is by nature capable. It is not through a merely native taste or bias, that these men pursue the science they have created. Their science is to them more than a love: it is a religion. Their impelling principle is deeper than enthusiasm: it is an earnest sense of duty. These men, therefore, belong to that class whose characters command the highest respect, and whose opinions carry the largest weight among their fellow-men. They, too, like others, have availed themselves of the powerful machinery of associated effort. In many enlightened lands, social science associations hold their periodical meetings, and by means of the reports of their discussions, scattered among the people through the public prints, and the wide circulation of their own memoirs and journals. powerfully impress the public mind. Within the past ten or fifteen years, there has sprung up, in addition to the national organizations here referred to, an International Social Science Association also, composed of men of every land, many of them men whose names have a world-wide celebrity. The

last meeting of this influential body was held in 1867 ; the next is to assemble in England, during the ensuing fall. Among other measures adopted at the meeting preceding the last, was the appointment of a committee to draw up a complete code of international law, to be presented for acceptance to the governments of all nations, and to be binding upon all such as shall assent to its provisions. The code is to comprehend two grand divisions, presenting the rights and duties of nations, first in peace, and secondly in war. The first of these divisions, relating to peace, is now complete, and will be presented to the association at the ensuing meeting. I am authoritatively informed that it embraces provisions making the metric system of weights and measures, the common system for all the nations accepting the code ; and there can be no doubt that the association will cordially concur with their committee as to these provisions. The Social Science Associations may therefore be regarded as another powerful influence, silently acting throughout every corner of every civilized land, and throwing its whole strength in favor of the universal adoption of the metric system of weights and measures.

There are other influences co-operating with this, in which the political principle is combined with the social. The importance of endeavoring, in some way or other, to arrive at a common system of moneys, weights and measures, has been felt by governments to be sufficient to justify the calling of international conferences to discuss this very thing. Now, though these conferences have not resulted as yet in bringing actually to pass the object for which they were summoned, still they have furnished an independent and an important vindication of the extent to which public opininion everywhere is turning toward the metric system, as destined inevitably to be at length the system of all mankind. For while the money question has invariably elicited a large variety of opinion, and an agreement of all the delegates upon any one proposition for the unification of the coinage of the world has been found extremely difficult if not impossible to secure, yet as to the question of weights and measures, there has been no difficulty whatever. At the Paris conference of 1867, for example, 22 nations were represented, including the non-metric nations, Russia, Austria, Sweden, Denmark, Great Britain, the United States and Turkey. The committee report in favor of the metric system was an admirable document drawn up by the celebrated De Jacobi, of St. Petersburg, and it received the absolutely unanimous concurrence of all the delegates of all the nations. It is impossible to regard a phenomenon of this kind, without seeing in it both an indication and an influence—an indication showing the march of opinion hitherto, and an influence which cannot fail to be felt in accelerating this march.

But there is still another and more powerful influence, uniting like that last mentioned, the social and political features, which has been gradually taking shape and gathering strength within the past twenty years, which is also destined to act powerfully in favor of the speedy creation of an international system of weights and measures, and which is already committed in advance to the metric system for that purpose. In explanation of this remark I will state that, about twenty years ago, there was assembled at Brussels, on the invitation of the Government of Belgium, a convention which assumed the name of "the First International Statistical Congress." This body consisted of 236 members, who were about equally divided between Belgium and foreign countries, thirty-five being delegates appointed by governments. This first convention, held in 1853, has been followed by six others, of which the second was assembled in Paris, in 1855, the third at Vienna, in 1857, the fourth at London, in 1860, the fifth at Berlin, in 1863, the sixth at Florence, in 1867, and the seventh at the Hague, in 1869. The spirit which these great international assemblages originated is explained in the following brief extract from the report of Mr. S. B. Ruggles, of New York, the delegate from the United States,* to the convention of 1869, at the Hague, recently published by order of the United States Senate. "The distinguished promoters of the first Congress, at Brussels," says Mr. Ruggles, "had seen enough of modern statesmanship to know that the government of nations in their present state of material progress, cannot be wisely conducted

* Mr. Ruggles also ably represented the United States in the fifth Congress at Berlin.

without a thorough knowledge of quantities;" and that the systematic collection and philosophical arrangement of the "quantities" needed for showing the general condition of nations, was an indispensable preliminary to any recommendation by an international Congress of any measures seeking to promote the general welfare." In accordance with this spirit, "the Official Report (or 'compte rendu') of the Congress at Brussels, shows its labors to have been largely devoted to the scientific analysis of quantities, in subjects interesting to all nations, to be used as a basis of a uniform system of inquiries, in actually collecting the necessary facts." And in like manner all the succeeding Congresses have devoted themselves sedulously to the labor of bringing together every description of facts obtainable, in regard to the actual wealth, the productions, natural and artificial, the condition of industry and commerce, the character of the social institutions, and other matters of kindred interest, relating to the various peoples who make up the population of the globe. The results of such inquiries could only be made available for any useful purpose, on the condition that all the "quantities" so ascertained should be reduced to a form in which they could be compared; on the condition, therefore, that they should be expressed in denominations of the same system of weights and measures; and accordingly it has been urgently recommended by all these Congresses, that all statistical statements everywhere should be made in terms of the metric system. The seventh and most recent of these assemblies, moreover, inaugurated a work which, if efficiently prosecuted, will be in honorable harmony with the magnificence of the idea which originated these Congresses of the nations. The nature of this work is thus stated by Mr. Ruggles: "On the last day of the session, Dr. Engel, the distinguished director of the statistical bureau of Prussia, presented to the body, in general assembly, a plan of great comprehensiveness and importance, which had been matured after full discussion in the appropriate section, and conversation with most of the governmental delegates. It provides for a full and systematic exploration of the whole field of international statistical inquiry, which is divided for that purpose under twenty-four different heads, each to be the subject of a separate investigation by the delegates or members from some one of the nations to be selected, and which is to embrace the statistics under that head, of all the nations. The great work, if fully carried out, will furnish, in convenient encyclopedistic form, a systematic series of carefully prepared reports on most of the subjects of highest interest to the statesmen and legislators of the different nations. Editions of at least two thousand copies of each report are to be published in uniform octavo volumes, under regulations presented in the plan, which was unanimously adopted by the Congress, with strong expressions of approbation."

Without the metric system, the vast mass of information thus collected would be unavailable; the encyclopedia would be illegible. This system has, therefore, thus become something more than a mere instrumentality in the service of statistical science, it has become even an integral part of the science itself. Henceforth the two are so irrevocably wedded that they can be separated no more for ever.

The "International Statistical Congress" may now be regarded as an established institution. Its eighth meeting in order of succession will be held some time during the course of the year 1871, and probably in St. Peterburg. Already the influence of its deliberations, of the published results of its labors, and of the spirit of comprehensive statesmanship which it has inculcated and fostered, is beginning to be sensibly felt, and with each successive decade of years it will be felt with a power continually increasing, in educating the minds of the peoples, and in moulding the counsels of governments into harmony with the great principle that nations only then consult their truest interests when they consult the common interests of humanity.

The germ idea of an agency which, with time, has developed itself into a power capable of controlling and destined so largely to control the future of human history, is to be found in the report of Mr. Adams to the House of Representatives of the United States Congress, made in 1821, which has been already cited in this paper. Though this report discouraged the adoption of the metric system by Congress, and though its reasonings had the effect undoubtedly

to impress the popular mind in this country with the conviction that the introduction of the system into these States is hopeless, yet the author himself was as deeply imbued with admiration of this system, considered as a scientific creation, as the warmest of its advocates; and no one felt more profoundly than he how great would be the boon to humanity if one uniform system of weights, measures, and moneys, could be made to prevail everywhere throughout the world. In the view of his large and statesman-like intellect, very many of the embarrassments which attend intercourse between nations, spring from the narrow and selfish legislation which looks only to the immediate interests or convenience of particular communities, and disregards the results to the great family of man. To him all nations and all races are brothers by blood, inheriting the earth as their common patrimony; and though, in the existing state of human society, it is necessary that the artificial lines which divide States from each other should be preserved, it is eminently desirable that for as many purposes as possible, they should be kept out of sight. He, therefore, proposed that the President of the United States should be authorized to invite the governments of the several States having diplomatic relations with that of the Union, to appoint delegates to a Congress of nations, charged with the duty of deliberating upon measures likely to be promotive of the general welfare; but foremost, and especially upon the possibility of establishing a uniform system of weights and measures for all mankind. That this important proposition was productive of no immediate results is attributed by Mr. Ruggles, and with apparent justice, to the political condition of Europe during all the earlier portion of this century, and especially to that compact of political rulers for the suppression of liberal thought, and the stifling of all freedom of political discussion, which the momentous events of recent history have since shattered, known as "the Holy Alliance." Happily, however, at length, to use the vigorous words of Mr. Ruggles, "We find the germ of the general convention, planted by the far-seeing sagacity of Mr. Adams in 1821, though slumbering for a generation beneath the surface, actually fruitifying in 1853, when the first general assemblage of nations by government delegates, and really international in its objects, was convened in Brussels." From this epoch dates a new era in the history of the world's legislation. For the enlarged views of the reciprocal duties, as well as of the true interests of nations in which this great general movement originated, are destined through its instrumentality to impress themselves more and more completely upon human institutions, until statutes shall at length cease to be monuments of ignorance, prejudice, or ignoble jealousies, and the aim of all laws shall be the greatest good of the greatest number. One most important result has already been secured by the action of these Congresses, in that so far as the science of statistics is concerned, so far, we may even say, as the successful conduct of governmental administration is concerned, it has made the metric system of weights and measures a system of universal necessity, and has made a familiar acquaintance with it absolutely indispensable to every statesman, every publicist, every teacher or student of political economy, and every enlightened lawgiver throughout the world.

It thus appears that there are powerful, permanent, and all-pervading influences steadily at work to advance the cause of metrological reform, and that these influences conspire to forward the movement in the direction which it had already spontaneously taken, that is to say toward the ultimate prevalence of the metric system of weights and measures over every other. It further appears that the actual progress which the movement has made since the century began, has by far exceeded anything which could have been reasonably anticipated, and has been sufficient to justify the most sanguine hopes for the future. When we consider, for example, that, at the close of the last century, the simple measure of length called the foot had not less than fifty values still, probably many more, actually in use in different parts of Europe, and that in 1867, at an Exposition in which the measures of all the world were all brought together, there could be found only eight of this discordant class still surviving, argument would seem to be needless in behalf of a cause which is so manifestly making its own way unaided. Whether our own people are to

be participators in this grand movement which has already gone so far, is not with me a question of probabilities, but only a question of time. I expect very little to-day, and not much to-morrow; but beyond to-day and to-morrow there are other days coming, from which I expect everything. I know the strength of early associations and the power of rooted habits; I know how fondly men will hug the evil which is familiar and reject the good that is strange. I know that the Greenlander greatly prefers his icy mountains to the coral strands of India. My inference is, that we must look to a generation which shall not be so mentally one-sided as ours; a generation in whose training the good shall not be placed at so tremendous a disadvantage as it has been in our own; a generation which shall bring to this great metrological question a judgment at once fair, candid, unbiased, and unwarped by the prejudices which mislead and bewilder us, to pronounce the impartial decision for which, it must be sadly admitted, we seem disqualified ourselves. And such a generation, gentlemen, permit me to predict, will yet be born upon the American continent, if it is not born already.

THE MONT CENIS TUNNEL.

(*Continued from page* 341.)

Having in my last letter given a general idea of the disposition of the external works and workshops at Bardonnèche, I need not describe those at Modane, which are in their principal parts similar. There is only one essential difference between the two, arising from the difference in the local conditions: At Bardonnèche the opening of the tunnel is at the same level (or nearly) as the workshops, whereas, at Modane, it is at a considerable height above them. An inclined plane was therefore established at Modane, on which everything was conveyed up to the mouth of the tunnel from the workshops and the working yards down below.

The motive power in working this inclined plane is the weight of a mass of water confined in receivers adapted for the purpose, which travel up and down the incline, and pull up with their weight (properly regulated by the admission of a greater or smaller quantity of water) the cars loaded with the material, tools, and implements, etc., required for the tunnelling.

MECHANICAL APPLIANCES IN THE MOUNT CENIS TUNNEL.

The mechanical appliances employed in the Mount Cenis Tunnel consist of two separate parts:

1. The plant outside the tunnel.
2. The mechanical means employed in the tunnel for the excavation of the rock itself.

The former may be subdivided into—

(*a*) Ventilation.

(*b*) Transmission of motive power.

The latter consists of—

(*a*) The perforation by the machinery invented by M. Sommeiller, of the holes for blasting.

(*b*) Blasting.

(*c*) Clearing away of the excavated rock.

The requirement of special ventilation and of special excavating appliances, as well as the absolute necessity of a particular kind of motive power, is self-evident when the length of the Mount Cenis Tunnel is taken into consideration.

All who ever have carried on mining are aware of the importance and difficulty of ventilation, when the length of the tunnel becomes excessive. It may be interesting to offer a few remarks on this subject, having a special reference to the means employed in the work we are now describing.

The causes of the vitiation of air in tunnels* are the blasting of the mines and consequent explosion of gunpowder, the combustion of tamps, and the respiration of the workmen.

One pound of gunpowder exploding produces

0.49 lb. carbonic acid gas.
0.10 " oxygen.
0.41 " sulphide of potash.

Now, as atmospheric air fit for respiration only can contain about 5 per cent. of

* J. Fettarappa, C. E.

carbonic acid gas, the explosion of 1 lb. of gunpowder is capable of vitiating $\frac{0.49}{0.005}$ lb., that is 100 lbs. of air, or speaking in volume instead of weight, 45 cubic yards of air, 1 cubic yard of air weighing in round numbers 2.18 lbs.

However, the carbonic acid is not the only gas produced calculated to render air unfit for respiration.

The proportion of oxygen in the air is nearly permanent, being 79 per cent., and if this percentage is increased, air becomes unfit for breathing.

Further, sulphide of potash considerably vitiates air, and hence we may safely admit that 1 lb. of burnt gunpowder impregnates 148½ cubic yards of air.

Now practice has shown that in order to render air fit for respiration in a place where there is no current, from 10 to 13 cubic yards of fresh air per hour have to be introduced for very man employed.

Further, to replace the air consumed by the combustion of each miner's lamp, about 9 cubic yards of air are wanted per hour.

Let us now consider the quantity of air which would have to be consumed for 130 cubic yards of excavated material, excavation being carried on with ordinary means. Practice has shown that in order to excavate 130 cubic yards of hard rock, 400 blasts are required, and 176 lbs. of gunpowder are consumed; further to make 400 blasts 214 days' work are required, calculating a day's work as 12 hours; and, again, as in a gallery, masons, carpenters, etc., are wanted, we may add 120 days' work of 12 hours each.

Supposing, then, that 130 cubic yards of rock should be extracted in 24 hours; during this period of time we shall have to introduce:

	cubic yards.
For 107 miners, and 60 other workmen	52,424
About 83 oil lamps	18,238
To replace the air vitiated by the explosion of 176 lbs. of gunpowder	26,160
For every 130 cubic yards of rock extracted	96,822

Cubic yards of fresh air is required.

Now the section of the tunnel of the Alps having 71¾ sq. yards, in order to advance 1 yard in length in the excavation, if ordinary means were used, about 53,400 cube yards of air would be consumed, and as the total length of the tunnel is 13,364 yards, to perforate it entirely, over 710,000,000 cubic yards of air would be consumed.

Further, the temperature of air must be kept within certain limits to maintain the workmen in a proper condition.

We know that approximately for every 98 ft. of depth attained from the surface of the earth, temperature increases 180 deg. The height of the mountain under which the Mount Cenis Tunnel passes being 5,285 ft., the temperature in the tunnel would be 127.40 deg.; to which we should further add the temperature produced by the burning of gunpowder and the combustion of lamps; we may safely assume the temperature to be 140 deg.

These considerations will clearly show the absolute necessity of a very efficient system of ventilation being adopted, without which the execution of the work would have been utterly impossible; further, the ordinary means used by miners for ventilation were not sufficient, nor indeed were they applicable.

These ordinary means consist of fans which are placed at the mouth of the tunnel, which is divided into an upper and lower chamber, in order to allow the vitiated and more heated air to be drawn along the upper part, and to be replaced by pure air along the lower part of the gallery.

But in tunnels of such excessive length, not only hours, but days would be required before pure air would arrive to the headings, even were the causes of the vitiation of air not permanent.

Hence it was necessary to carry along with great velocity, and compassed in a small volume, a sufficient quantity of air precisely to those parts of the tunnel where the works were concentrated, and the permanent causes of the vitiation of the air existed; or, to speak more correctly, it was indispensable to combine the two means of ventilation.

The exhausting machinery at Bardonnèche consists of a tangential turbine, moved by a column of water 65.7 in. in height. The theoretical velocity is 87 revolutions per minute, and about 40 cube yards of air can be extracted with it per second.

At Modane the exhausting machinery consists of an ordinary pump. As regards the machinery with which compressed air was sent along to the heading in the tun-

nel, they were the same as those with which the motive power was produced, and will be described presently; in fact, the introduction of compressed air in the heading was effected by opening cocks along the tubes which carried the motive power. There certainly was a great inconvenience in using compressed air in the ventilation, owing to the consequent loss of useful work. Let us form an idea of this loss by estimating the quantity of work which can be performed by a cubic metre of compressed air.

$\int p\, d\, v$ represents the work which gas produces in expansion. If we suppose that the gas in expanding absorbs so much heat from the surrounding gas, that its temperature becomes equal to that of the latter, the equation of elasticity of the air will be $p\, v = \mathrm{R}\, t = \cos t$, and hence:

$$\int p\, dv = \int \mathrm{R}\, t \frac{d\, v}{v} = \mathrm{R}\, t \int \frac{d\, v}{v} =$$

$$\mathrm{R}\, t \log v + \cos t,$$

will express the work done by the gas through expansion.

And as its temperature remains constant, Mariotte's law receives an application; the compressed air being supposed by us to expand from a pressure of six atmospheres to that of air, its volume from v_1 will pass to v_0, so far that $v_0 = 3v_1$, and hence the work which the air through its expansion is capable of producing, will be given by the expression:

$$\int_{v_1}^{v_0} r\, d\, v = \mathrm{R}\, t \log \frac{v_0}{v_0} = \mathrm{R}\, t \log 6,$$

or passing from the Napierian to decimal logarithms,

$$\mathrm{R}\, t \log 6 \times 2.30\,;$$

the constant for air is $\mathrm{R} = 29,\ 27$.

The temperature, $t = \propto + t = 273 + t$, which we will suppose 300 deg. centigrade, and completing the calculation we find 15,718 kilogrammetres as the result.

This calculation refers to 1 kilog. of compressed air, and 1 metre cube of air weighing 1.3 kilog., according to Mariotte's law, the cubic metre of compressed air expanding from the pressures of 6 atmospheres down to that of 1 atmosphere, its volume will become 6 metres cube or nearly, and the weight will be 7.80 kilog.; thus 1 metre cube of air compressed to 6 atmospheres, and expanding down to 1 atmosphere, develops useful work equivalent to 15,718 kilogrammetres$\times$7.8=122,600 kilogrammetres.

This quantity of work lost by the application of 1 metre cube of air compressed to 6 atmospheres for ventilation is certainly enormous. However, the loss had to be submitted to, in order to make respiration and continual work at the heading possible.

WORKING TORPEDOES.*

By PHILIP BRAHAM.

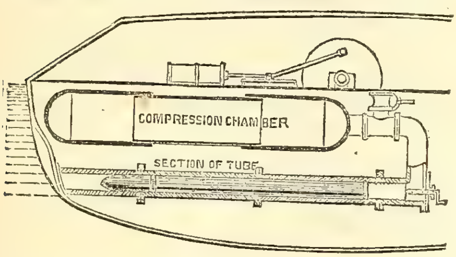
From "Engineering."

The exigencies of modern warfare requiring the greatest amount of damage to be done in the shortest amount of time, and naval warfare being the principal defence of England, the question of using torpedoes has long engaged attention. These destructive implements of war are mere bodies of explosive material, either placed in the way or brought in contact with the ship to be destroyed. The mode commonly adopted is to sink these machines to a slight depth below the water with a fuse at the top, which explodes it when a ship passes over and touches it. Another way is to sink them within view of a camera obscura, and marking the place on the table of that instrument, the wire with which it can be exploded is brought to the observer. A circle is marked on the table, within which the torpedo is effective, and when any aggressive ship comes within that circle, galvanic contact is made with the wire and the explosion is effected; these modes depend on the ship sailing to its own destruction. There is a proposition that at night a boat's crew might destroy a vessel by one of the party swimming to the ship and attaching a vessel of nitro-glycerine by means of pneumatic pressure, and exploding it by electricity. Another proposal is that two vessels should tow one of these machines

*Description of an apparatus for Workins To pedoes. Paper read before Section G of the British Association.

across the bows of the enemy and then explode it. Another proposition is that the torpedo should be stuck at the end of a bowsprit and run against the enemy.

The method I propose is to propel the torpedo from a ship below its water line by the expansion of compressed air. In the drawing you will perceive the apparatus consists of a chamber into which air can be compressed—a bored cast-iron tube through which the torpedo can be moved—a valve arrangement by which the progressive velocity of the torpedo is obtained, a sluice valve and breech plate, whereby another torpedo can be introduced when the first is expended. The torpedo itself consists of an explosion chamber at the pointed end, with a percussion fuse, a shaft of wood of any convenient length, and a corrugated cap of sufficient weight to make the whole nearly float horizontally. By means of compression pumps driven from the machinery which propels the ship, I propose to compress air into the compression chamber to 500 lbs. to the sq. in. When the apparatus is within striking distance of the object attacked, by turning the lever of a four-



way cock the air will find its way under the piston in the small cylinder, which will rise, and with it draw the brass valve opening a port of the shape shown in black. The first opening of the valve will allow but little air to escape (to overcome the vis inertiæ and friction of the torpedo and the column of water in front of it); then the aperture rapidly increasing in area as the valve pipe rises, a steadily progressive velocity will be imparted to the torpedo of sufficient energy to carry it in a straight line far beyond the ship. By the reaction of the force driving the torpedo forward, the ship will have its speed considerably diminished, if not entirely neutralized. With sunk torpedoes two boats at night with a rope between them could easily fish them up. The diving suggestion would be impracticable in any but still water. The drawing across the bows would depend upon two ships, which are not easy to control in unison. The running end on might involve you in the destruction intended for the enemy, and would bring you unpleasantly near their fire. In my arrangement it must be allowed that the torpedo will be effective at its own length from the bow, and also at double that distance. The reaction from sending this body forward with an elastic pressure, whose average statical force would be not less than 85 tons on the diameter of 1 ft. 9 in. shown, would certainly act like a buffer, and considerably retard the motion of the ship.

A new and very commodious station was opened recently at Pontefract for the convenience of the inhabitants residing at the Tanshelf end of the town, as well as for the accommodation of the vast traffic during the race meetings at that town. The building is composed of pressed red and white bricks, and is set apart as a booking and station-master's office, general and ladies' and gentlemen's waiting rooms. Two very lengthy platforms, 15 ft. in width, have been provided, with 5 gas lights on each side. The contractor for the work is Mr. Gregson, of Wakefield. Five trains arrive and depart from the station daily, which cannot but prove a great convenience to the inhabitants, who, in a short time, will be brought into the immediate locality by the opening out of several new collieries. The station has been built by the Lancashire and Yorkshire Railway Company.

Mr. Charles Dion, of New York, proposes to place an apparatus on board of steamers and other vessels, so arranged as to sound an alarm on approaching the vicinity of an iceberg. The device is arranged on the bottom of the vessel, and is of such a nature that when the keel strikes any very cold strata of water the alarm is sounded. It is well known that icebergs refrigerate the water around them for a considerable distance. Mr. Dion's instrument will exhibit the exact temperature of the water below the vessel at all times.

WHAT IS BEING DONE TO PREVENT STEAM-BOILER EXPLOSIONS?

By ROBERT CREUZBAUR.

After every unusual calamitous boiler explosion, the subject is taken up again and again for discussion ; but, so far, without any results to which we can look for future immunity.

The discussions usually run in two extremes—either laying the cause entirely to weakness in the construction of the boiler ; or, on the other hand, to causes entirely independent of the strain-resisting capacity of the same. These extreme views generally counteract each other, and nothing results. The proposition herein emphatically advocated is this, that however much difference of opinion as to the precise causes of explosions may continue to exist, an overwhelming plurality of sound opinions can agree upon few and simple remedies, capable of counteracting all the causes mooted. These remedies do not necessitate the use of anybody's patent, but are free to all.

With the best efforts to cling to brevity, it is impossible to handle the subject intelligently in a short article. But, as a matter in which every person is directly interested, strictly necessary departure from brevity may be allowed.

Public expectation turned to the Westfield explosion ; and particularly to the report of the able officers of the Government on the subject. From that report it is evident that its framers lay all their trust in the power of resistance of the boiler. And although the injurious effect of unequal expansion is especially referred to, no means are proposed to prevent it. The report says : " . . . the explosion was produced, we think, by a pressure not much in excess of the engineer's statement" (27 lbs.). "We cannot, of course, say that this boiler would not have exploded during the time of one year from the date of the last inspection, had the pressure been confined within the limits prescribed by the inspector's certificate ; but the inference is a legitimate one, that it would not have exploded at the time it did; and it is fair to presume that it might have been used until the end of 12 months without accident." Here, then, is an admission that, had the engineer been ever so careful, the boiler might have exploded within the year, notwithstanding the inspection and the locked safety valve, and the certificate to its power of resistance. Comment on this is unnecessary. The people's dread of boilers is certainly not allayed by this report ; nor are Messrs. Boole and Hill satisfied with the slender security portrayed in it.

The community may, however, feel reassured by the fact that the public officers in charge of the matter are men of too much experience, too great ability, and too sincerely in earnest in their desire to give security to the people in the matter, to allow any conviction of their own as to the cause of boiler explosions to stand in the way of the adoption of remedial measures, which, while fully covering their own view of the causes, would also cover all other views sustained by authorities commanding equal respect. Younger men, with less ability, would be inclined to stand by their own opinions. But older men, of superior acquirements and enlarged experience, generally learn how cautiously conclusions must be arrived at, and are more ready to admit a doubt as to the soundness of preconceived and habitually followed ideas.

Differences of opinion on this subject are not surprising, when it is remembered that, in the words of Prof. Tyndall, "We are more ignorant of these things than we ought to be. Experimental science has brought a series of true causes to light, which may produce these terrible catastrophes, but practical science has not yet determined the extent to which they actually come into operation." The true causes of violent explosions have but recently been urged, and have not as yet generally received that attention which will no doubt be bestowed upon them hereafter. Many of the ablest engineers have found themselves too closely engaged, by the very reason of their superior abilities, to keep step by constant reading with recent experimental science, which proves that causes, formerly discarded by the educated professional engineer, are too well based on fixed laws of nature to be longer ignored.

Before proceeding farther I cannot re-

frain from making allusion to the popular belief as to the relation to each other of science and practice. There is too much inclination to believe the two as antagonistic. The practical community, purely so, is too apt to believe science as unnecessary, and as worthless when seemingly in conflict with their views culled from practice only. This is totally wrong, and is apt to lead to baneful results. What is science? It is the utilizing of knowledge obtained by experience and experiments, so as to apply it to endless other matter with useful results, which, by practice alone, might never be reached. Solitary facts ascertained by practice, are put together to form theories applicable to endless purposes. Facts ascertained by experimental and practical experience, are, figuratively, as the blocks of stone out of which the priceless temple of knowledge is constructed. Without the experimental and practical work the scientific men could never have built that temple for want of material. Hence to reach a maximum of usefulness let them go hand in hand.

Too much stress is generally laid upon personal experience, and is made particularly prominent in this boiler explosion investigation. Men of 30 and 40 years of "practical experience" made assertions totally at variance with that of thousands of others who trained their experience by that of others well proved. Practical men, who do not test their conclusions by the recorded proven experience of so many illustrious men who preceded them, are but too apt to check progress by erroneous statements, not of the facts ascertained, but of the causes they assume to produce such facts. A man, without knowledge of recorded experience, may, for 40 years, handle the starting bar, or build and manage boilers and engines, or superintend the doing of it, and yet know nothing of the nature of steam, of water, of heat, of combustion—in fact, is doing his work at the risk of explosions and other mishaps, by following a groove of habit in which he has learned to travel, and out of which it is extremely difficult to draw him. Let it be remembered that all personal experiences and opinions must be weighed by, and compared with, that of thousands of others, and, by laws of nature, which to deny were as idle as to deny the correctness of the multiplication table.

The proposition herein advanced is this: Perfe t continuous circulation in a boiler, both in the water and steam spaces will prevent all explosions by whatsoever cause, provided it has been proven of due strength by a properly conducted inspection, and is duly supplied with appurtenances.

To prove this, the alleged causes must be, more or less briefly, looked into.

The suggested prominent causes of explosions may be ranged in four classes:

Class A, comprises all that tends to weaken the power of resistance of the boiler.

Classes B, C and D, comprise all causes to which explosions are attributed, without reference to the power of resistance of the boiler.

To class A belong: Imperfect materials. Imperfect mode of putting the parts together. Want of provision for unequal expansion and contraction. Deterioration of materials while in use. As to these, there is very little difference of opinion, hence, no necessity to dwell upon them. It must be remarked, however, that unequal expansion caused by unusual overheating of the metal, it is claimed, is sometimes so excessive as to be the direct as well indirect cause of explosion in the manner named here below.

To Class B belong: Safety valves which refuse to relieve the boiler at the fixed limit of pressure. Inefficient pressure and test gauges. Want of proper connections, and other requirements about all of which there is no dispute.

To Class C belong: Incrustations. Low water. And now come alleged causes ranged in Class D, about which there exist great differences of opinion. Some of these, if not provided against, are considered capable to override all other possible precautions, and to produce the most violent explosions. These are:

1. Highly superheated steam, by its alleged capacity to create a sudden conversion of water into steam.

2. Rapid formation of steam by red-hot plates.

3. Decomposition of steam by red-hot plates, and explosion of the resultant hydrogen gas by commixture with oxygen, etc.

The following three causes may be considered jointly :

4. Repulsion of water by overheated metal, called "the spheroidal state" of water.

5. Narrow water spaces around intensely heated fire spaces,—also resulting in overheated metal and the "spheroidal state of water."

6. The capacity of quiescent water, when deprived of air, to accumulate a large amount of heat over and above that due to its pressure, which flashes into steam.

7. To this may be added electrical and atmospheric influences.

To review these :

1. Is superheated steam capable of producing an explosion ? During the investigation referred to, two distinguished engineers, "of many years experience," have answered that question in the affirmative Upon closer investigation they would no doubt express a modified opinion. Let us see : Steam at 25 lbs. pressure has a normal heat of 267 deg. Suppose 700 cubic ft. of such steam be overheated (superheated) to an average of 500 deg.,—233 deg. above its normal heat. 700 cubic ft., or 70 lbs., require $70 \times 233 \times 0.85$, or 13.863 units of heat to be thus heated. It takes 926 units to convert 1 lb. of water at 276 deg. into steam ; 13,863 less about 500 units absorbed by the steam at the higher pressure, will produce about $14\frac{1}{2}$ lbs. of steam, which would increase the pressure to about 33 lbs. This is the greatest effect such superheating could produce, and is only possible on the supposition that none of the heat is absorbed by the water not so evaporated, which under this increase of pressure has the capacity to absorb nearly 20 additional units per lb. without forming steam. And it also assumes an extreme in this, that all the steam must become normal in heat, that is, of 286 deg. It must, moreover, be remembered that this increased pressure could only be produced gradually, in fact less rapidly, on account of steam being a bad conductor, than if the steam were formed by heat transmitted through the plates directly to the water. If the steam, by some means, were violently mixed with the water, a sudden formation of steam would even then not take place, because of the capacity of the water to absorb large quantities of heat under increasing pressure. The water, of a bulk equal to the steam space, can absorb those 13.863 units of heat without raising its temperature more than about one-third of one deg., if equally transmitted throughout the same,—with an increase of pressure hardly appreciable. This is, however, another extreme assumption, as in a boiler without good circulation, the upper water only would come in contact with the superheated steam. Therefore, the effect of superheated steam in increasing pressure, can be no more rapid than by the application of heat to the water in a normal manner, from the furnace through the metal directly, and thus such steam can be no greater source of explosion than any normal transmission of heat whatever.

The investigations of the Franklin Institute, as stated by its Secretary in a letter of Sept. 4, 1871, which I have the honor herewith to submit, are averse to the proposition that superheated steam can produce explosion.

But whatever the effect of such steam may still be supposed to be by some of its advocates, the prominent remedy which is intended to be urged throughout this paper as universal against explosions from all causes belonging to classes C and D, is perfect and continuous circulation throughout the boiler.

2. Will red-hot plates, suddenly brought in contact with water, form steam of explosive force ? That is, does it form steam very suddenly and in a dangerous manner as compared to the normal mode of producing steam. The decomposition of steam is not to be considered under this head, but simply the direct evaporating powers of the hot iron. Let a surface $\frac{1}{4}$ in. thick, 6 ft. wide (the top of 6 flues), 20 ft. long, be supposed to have become heated to 1,200 deg., or about 850 deg. above its usual heat. This is certainly an extreme supposition. The bulk would be $6 \times 20 \times 0.25$, divided by 12, equal to $2\frac{1}{2}$ cubic ft. or 1.215 lbs. The units of heat required to raise this weight of iron through 850 deg. would be $1,215 \times 850 \times 0.12$, equal to 123,930 units. The units of heat above 32 deg. contained in the water and steam (700 cubic ft. of each) at 25 lbs. pressure, amount to 10,450,000 units, or about 84 times as much as the surplus contained in the heated iron ; the latter would not be sufficient to heat the whole mass to correspond to a pressure of two additional

lbs. But if, as most likely would be the case, the majority of the heat would produce steam without heating the bulk of the water, the pressure would be very much increased. If no heat were absorbed by the water not evaporated, the greatest assumable result would be an addition of some 134 lbs. of steam to the 70 lbs. already on hand. But this, as in the former case, cannot take place suddenly,—nor as rapidly as the application of the same amount of heat in the usual way, until the iron has become considerably cooled. When so cooled, you have nothing more than unobjectionable highly efficient heating surface, upon which point the instructive letter aforesaid remarks: "The temperature of the maximum evaporation from metallic surfaces increases with the quantity of water brought into contact with them," and is only about 40 deg. lower than that of perfect repulsion. This again points to circulation. The letter farther says· "Explosive steam may be generated by the injection of water upon red hot iron," and that "the committee reproduced the phenomenon of a miniature explosion fron the cause here named;" reference is made to Vol. XVIII., p. 16 "Journal Franklin Institute." This result cannot be ascribed to the evaporative capacity of the hot iron, but is brought about by cause 4, which fully explains it, as shown farther on. The evaporative capacity of red hot iron can therefore, as such, not be productive of explosion, any more so than an equal amount of heat applied in the usual desirable way in the most efficacious manner. The injuiy would be caused by the great expansion of the parts so heated, and by reduced resistance of the iron itself. And the question is, how much heat has accumulated in the water during the repulsion, ready to flash into steam of explosive force. In the spheroidal state, experiments show the water not to accumulate heat; but the spheroidal and quiescent or deaerated state of water may sometimes occur, in fact are they not likely to occur at the same time? In this case again, perfect circulation in the water and steam is urged as the best remedy known. This does not mean, however, that the proper water level should be neglected. It should on the contrary be made as nearly constant as automatic means can make it.

3. Decomposition of steam by red hot plates, and alleged consequent explosion. That this can take place is as pertinaciously asserted by the purely practical men, as it is denied by the scientific men. The aforesaid letter says: "The reply of the committee as to the truth or falsity of the 'Gas Theory' is decided. They find no reason for supporting it, and their experiments (Vol. XVII., p. 217), as well as the universal sentiment of scientific men, will condemn it as unworthy of being seriously entertained." The same view is held by Faraday as related on p. 8, Jan. 4, 1868, "Scientific American." Nevertheless, a feeling of insecurity in this respect is not surprising, when cases as the following are reflected upon. That hydrogen gas is set free under such circumstances is not denied by either side. The only question is, can sufficient oxygen be mixed with it in a boiler to make it explosive,—and will the red hot iron ignite it in the steam space?

On p. 35 Vol. XIX., July, 1868, "Scientific American," an interesting case is given: "The supply pipe refused to deliver water, and the engineer prudently drew his fire; 24 hours after, the engineer opened the man-hole to see if any damage had been done by overheating. He introduced a lamp, when an explosion occurred sending the engineer through a wooden partition," etc. An explanation of this is given on p. 118, Aug. 19, 1868, "Scientific American," by Doctor Vander Weyde, the correctness of which is not likely to be disputed,—as follows: "Some part of the boiler became hot enough to decompose steam, not into its elements (this is pure speculation, having no fact to support it), but the iron became oxidized by the oxygen of the water, and the hydrogen was set free, which is always the case when steam is in contact with red hot iron. It is, in fact, one of the ways to manufacture hydrogen. The boiler being closed, and the hydrogen not soluble in water, it remained there; when the manhole was opened, air enough entered to form with the hydrogen an explosive mixture, to which the engineer set fire with his lamp." To this he adds in substance: "Had there been oxygen and hydrogen mechanically mixed, in the proportion as chemically combined in water, something much worse would have happened to the engineer and the boiler also. In this case, it was simply hydrogen and common air,

which may be considered almost harmless when compared with the tremendous power of hydrogen and oxygen."

The legitimate deduction from this is, that a very little oxygen mixed with the hydrogen can cause a little explosion, and more oxygen a greater one, and so on. This is strikingly supported on p. 10, July 3, 1869, "Scientific American," the article relating a misadventure that happened to Prof. Silliman at a lecture, in explaining the properties of hydrogen: "After stating that on a lighted candle being applied to it, it would burn quietly with a bluish flame, he raised by its knob a glass receiver which he supposed was filled with the gas, and applied the candle. There was a violent explosion." He remarked: "This illustrates something that I was going to speak of by and by. A little oxygen was accidentally mixed with the hydrogen, and caused the explosion. We will now try another jar, which I presume we shall find pure."

Who will tell us with what minimum of oxygen the gas will not explode at all, and if ever so weak an explosion, can it be made a harmless phenomenon in a boiler? The steam is often mentioned as preventing the ignition of the hydrogen mixture. Is it not legitimate to admit that the gas, when first produced might be sufficiently separate from the steam for a time, they being also of totally different specific gravity, to ignite by contact with the hot iron? Is all the oxygen absorbed by the iron? Might not a sufficiency remain to cause a very gentle explosion? Does the feed-water carry in a supply sufficient for the purpose? How about iron when hot being permeable to hydrogen gas? If it fails to ignite 99 times, might it not do so the hundredth time?

I do do not say the "Gas Theory" is correct, but these are ideas that might make one set uneasily upon a boiler in which these experiments were going on. Again, perfect circulation in the boiler is the remedy. Before taking leave of local overheating of boilers, the injury done to the structure, independent of any other strain whatsoever, is strikingly illustrated by an incident given on p. 262, "Scientific American," Oct. 13, 1866: "A return flue boiler of 72 in. shell had its plates bulged over the furnace. While workmen were engaged in cutting them out, having chipped an opening of several inches in the forward end, the after end tore apart with a tremendous noise. The rupture took place in one of the transverse seams of the boiler, tearing the solid iron between the rivets about $\frac{1}{16}$ of an in. apart, and 1 ft. in length." This is purely the result of repeated local overheating.

As to the 4th, 5th, and 6th causes, embracing the repulsion of water by overheated metal, narrow water spaces around intensely heated fire spaces, and the capacity of quiescent deaerated water to accumulate a large amount of heat over and above that due to its pressure; about these the evidences to establish their reality are too strong to be thoughtlessly set aside. As they are more or less identical or related to each other, and result fatally in a similar manner, they are considered jointly. Before me is a pamphlet headed, "Is the Donny Theory, or 'Superheated,' or Deaerated Water a Fallacy?" by Geo. B. Brayton, Boston, who offers a reward of $1,000 for proof that water can be superheated as mentioned in the 6th clause. Mr. Brayton calls the theory "absurd," and Mr. A. Guthrie, late Supervising Inspector, who is quoted in the pamphlet, speaks of it thus: "That this theory has been copied into many works on chemistry and science, and assented to by learned men during 100 years, excites my wonder; but that it has not found its refutation in its own absurdity seems to me still more singular." Query: Did Mr. Guthrie think the matter absurd while he was making his experiments? If so, he could hardly be considered qualified for such delicate tests, which require a mind free of preconceived ideas as to the result, and one that can admit success in the experiment as possible; or does he call it absurd because he did not succeed in the experiments? Many more might make the attempt and not succeed; but that would not disprove that the experiment has been successfully made. And lucky that it is exceedingly difficult to fulfil all the conditions required to place water in that state, else there would be a great many explosions. Mr. Guthrie says: "I concede that Prof. Tyndall has in a measure given credit to this theory, but the moment after, and before concluding, he disclaims his belief in it so plainly that he need not be misunderstood." I have be-

fore me the 2d edition of Tyndall's Lectures on "Heat considered as a Mode of Motion," 1865. He explains this property of water on pages 113, 114, 115, and 116. He shows by actual experiment that water deprived of air in a glass tube has a different sound "like that of solid against solid," "that it refuses to behave like a liquid body," "it declines to obey the law of gravity." He says: "Water thus freed of air can be raised to a temperature 100 deg. F., and more, above its ordinary boiling point, without ebullition. But mark what takes place when the liquid does boil; it has an enormous excess of heat stored up; the locked atoms finally part company, but they do so with the violence of a spring which suddenly breaks under strong tension, and ebullition is converted into explosion." "That it does so has been proved by Mr. Faraday. He melted pure ice under spirit of turpentine, and found that the liquid thus formed could be heated far beyond its boiling point, and that the rupture of the liquid, by heating, took place with almost explosive violence." He states: "The number of explosions which have occurred just as the engineer turned on the steam is quite surprising." And after explaining the manner in which the cohesion of the water would bring about such explosions, he closes with, "I do not say this is the case, but who can say it is not the case? We have been dealing throughout with a real agency, which is certainly competent, if its power be invoked to produce the effects which have been ascribed to it." Where does Mr. Guthrie find any sentence indicating that he "disclaims his belief in it?" Is it the cautious exclamation, "I do not say this is the case?" This is an expression of caution natural to men on the pinnacle of science. They feel somewhat as the great philosopher of ancient times, who exclaimed on his death-bed, "I have learned enough to know that I know nothing!" Yes, the more these giants in knowledge learn, the humbler they are in their pretensions, and the more cautious in their assertions.

It is generally conceded that the French officials are capable and reliable. M. A. Ortolon, then Chief Engineer of the Imperial Marine, promulgated a paper upon premonitory indications of explosions. He does not pretend to explain the causes, but merely states the facts to him known to exist, and the remedies: "A fulminant explosion is rarely preceded by any characteristic signs; nevertheless the following phenomena are sometimes the precursors of the catastrophe. Steam alone appears in the gauge glass; although the fires may be strong the pressure falls on the pressure gauge; the boiler tubes and fire-box plates bend, assuming a lighter color; the safety valve rises suddenly, emitting a violent jet of water; the level of the water in the gauge glass remains completely immovable, whilst the pressure falls sensibly without apparent cause." These phenomena are in accordance with the spheroidal and cohesive state of the water. When the plates become too hot to remain in contact with the water, the formation of steam becomes very slow, hence the "falling of the pressure." The overheating of the plates increases as the formation of steam decreases. The water in resisting cohesion is finally violently thrown up, and thus escapes by the safety valve. He farther states: "Renew the water in part at each new lighting of the fire, if it has previously been heated and not completely cooled; this is in order not to leave for the production of steam a liquid from which the air has been completely expelled." Again, "When the engine has been stopped, do not allow the water and steam to remain a long time in the boiler in complete repose." Mr. Ortolon's experience and knowledge unquestionably point to causes 4, 5, and 6, and his remedies coincide with that herein urged.

The "Spheroidal State" theory Prof. Tyndall explained and proved by experiments, as related in the said work on pages 163 to 171 inclusive. He says: "Boiler explosions have also been ascribed to the water in the boiler assuming the spheroidal state, the sudden development of steam, by subsequent contact with the heated metal" (and by release of the heat stored in the water, if deaërated) "causing the explosion. We are more ignorant of these things than we ought to be. Experimental science has brought a series of true causes to light, which may produce these terrible catastrophes; but practical science has not yet determined the extent to which they actually come into operation." "Here is a copper vessel, with a neck stopped with a cork, through which

half an inch of fine glass tubing passes. I heat the copper vessel, and pour into it a little water. The liquid is now in the spheroidal state. I cork the vessel, and the small quantity of steam developed, while the water remains spheroidal, escapes through the glass tube. I now remove the vessel from the lamp, and wait for a minute or two: the water will soon come in contact with the copper; it now does so, and the cork is driven, as if by the explosion of gunpowder, to a considerable height into the air."

In a paper read by E. B. Marten before the Institution of Engineers of Scotland, May 31, 1870, is stated: "It has long been the object of engineers to obtain accurate records of every case of boiler explosion, and I have done my utmost to assist in that object, and have obtained notice of more than 1,500 explosions, causing the death of over 5,000 persons, and the injury of some 4,000 others." "The records are discouraging in many respects, as they contain the names of some of the best and most careful engineering firms as owners of exploded boilers, and also give instances of explosion of nearly every form of boiler which has been in use for any length of time." This would surely not be the case if the power of resistance of the boiler alone could be made to prevent explosions.

On p. 359 "Scientific American," Dec. 3, 1870, mention is made of the pamphlet of J. E. Robinson, steam engineer, Boston, which ought to be in the hands of every boiler manager. It embraces the following particularly notable points: "While it is true that the condition of many boilers now in use is such, that it is a matter of surprise that so few boiler explosions occur, having their origin in excessive pressure, overheating of the surfaces above the water, in defects of materials of construction, and in the presence of scale and sediment, it is also true that there have been so many explosions not attributable to either of these causes, as to point unmistakably to the existence and operation of a power not indicated by the pressure gauge." After giving accounts of a large number of such explosions, Mr. Robinson proceeds to account for such explosions by referring them to "overheating near the bottom of the boiler (by the spheroidal state of the boiler), causing the water to be thrown with such force as to break the top." He supports this by opinions of Boutigny, Bourne, and Colburn, and quotes the experiments made by a committee of the Franklin Institute, showing that the temperature for perfect repulsion for a clean steam boiler is 385 deg., and for one "highly oxidated, but clean," 433 deg. "The temperature of maximum vaporization is some 40 deg. lower." "At the temperature of perfect repulsion the water does not wet the metal." By elaborate experiments he ascertained that "The effect of pressure, accompanied by rapid circulation, so far overcomes the repulsion that, practically, the point of perfect repulsion may be said to be raised by the pressure within the boiler; but this only holds true so *long as there is perfect circulation* of the water, so as to bring it into forcible contact with such surface." "His experiments show, that whenever any part of the surface of a steam boiler much below the surface of the water is raised much above the temperature of maximum vaporization, the reduction of its temperature will be attended with such rapidity of vaporization as to endanger the boiler" (the danger is from other causes); and that, while in cases of perfect repulsion there will always be recognizable signs of trouble within the boiler, indicated by the steam and water gauges, in cases where the repulsion is not perfect, the danger may be incurred without any visible sign of its existence being manifested." This agrees with Ortolon's experience, above quoted.

A very simple experiment, within the reach of all, will sufficiently prove this spheroidal state. I made it with a cast-iron disk with turned-up edges, about 7 in. in diameter, and of $\frac{3}{8}$ in. average thickness. Being made red hot, and withdrawn from the fire, I poured from a teaspoon to a gill of water into it, during several experiments, with the result as above stated. The vapor produced during the repulsion is invisible, therefore supposed to be dry steam. A proof that forcible contact does overcome the repulsion, is obtained by dropping the water from a height of a few inches upon the hot iron, with the result of rapidly extracting the heat at the spot thus impinged upon, as shown by its immediate change of color to a dark red and gray. With the larger quantity of water in the vessel, as soon as the repulsion was overcome by the cooling of the iron, the rapid forma-

tion of cloudy steam in the central part of the disk ruptured it—the hotter outside rim not allowing the central part to contract. M. Boutigny and others maintain (and it is easily tested), that when the repulsion "has once taken place, the plate, being left dry, *may go on accumulating heat and rising in temperature for an indefinite time*, until some agitation, or the introduction of cold water, shall produce contact between the water and the plate, and bring about an explosion."

Mr. Joseph A. Miller, of New York, made some experiments to prove the importance of a *free circulation of water*. They are given and illustrated on p. 180 Vol. VI. (April 1, 1868), of the "American Artisan." Mr. Miller believes that no boiler with a proper safety valve can explode in which there is a perfect circulation, and in which the steam is made to leave the water as fast as generated ; or, to use his own language, "no boiler can explode which contains only dry steam and solid water, if a proper safety-valve is used." Mr. Miller wishes it to be understood that by explosion he means, not a simple rupture of the weakest part, letting out sufficient steam to reduce the pressure, but a violent action by which the steam, and generally all the water, are forced out. He took a flask "strong enough to stand a pressure of 50 lbs. to the square inch, on which I placed a safety-valve so arranged that it would lift suddenly at 30 lbs. pressure." "After the flask had been 15 minutes on the fire, the safety-valve opened entirely, a powerful jet of steam was forced out of the opening, and, instantly after, the flask burst with a loud report, shattered every pane of glass in the windows, and destroyed the plastering of the ceiling. The time between the two explosions was infinitely short, and seemed to me just sufficient to force the water against the upper part of the flask, when the whole was shattered into fragments." There was no special provision for circulation in this flask. The same experiment was repeated with a flask provided with a shield to cause circulation, which prevented all explosive action.

Upon the investigation of the Westfield explosion, the idea was advanced that no increased pressure is ever noticed upon starting the engine after the water in the boiler has been allowed to remain quiescent for a considerable time; the deduction being that no sudden development of steam takes place from heat accumulated in the water. To show this to be an error, I quote from "Engineering": "In many cases there is a sudden increase of pressure in steam boilers immediately after starting the engine." Even if such sudden increase of pressure were not observed, it is more than probable that the masses set in motion by explosive development of steam would destroy the boiler before an opportunity is had to examine the gauge; or before a sensible impression upon the latter is made through the reprehensible, crooked, and diminutive pipes leading to the same.

The two following explosions took place in this city, with identical new boilers, in an identical manner, and are worthy special notice. The Dinsmore upright boiler, illustrated in the "Scientific American," p. 357, Vol. XVI., June 8, 1867, has a peculiar construction which seems to obstruct circulation in the parts most exposed to intense heat. One of these boilers exploded "with terrible violence" on board the lighter Enterprise, on January 22d, 1867, just as the tug was entering her dock. The boiler was not quite one year old, and made of No. 2 iron, said to be of the first quality. The boat at the time was ramming her way through heavy ice. The boiler (some 12,000 lbs.) rose bodily from the boat, and fell in the rear of a wall, 40 ft. high, and at least 600 ft. distant, and could not have attained a height of less than 500 or 600 ft. "The tube cylinder (which is about 3 ft. below the common water level) seems to have given way first). See p. 168, Vol. XVI., "Scientific American."

Is it likely that, while ramming ice, the water would not be looked to?

On the 9th of September, same year, another Dinsmore boiler, weighing 5 tons, exploded about 4 P. M., at 258 W. 28th st., ascending into the air nearly vertically, appearing the size of a nail-keg, and falling into the rear part of No. 308 W. 28th st., a distance horizontally of about 450 ft. This boiler was new, having been in use less than two months and a half. The iron was pronounced of good quality by all practical iron men. On the afternoon of the explosion it was not doing more than about half its ordinary

work. The engine was running, and had not been stopped.

The lower tube head blew out, taking most of the tubes with it, which pulled out of the upper head, the latter being about 3 ft. below the usual water level, and 20 in. below the crown sheet. The same engineer and fireman (both killed) had been employed there, as such, about four years. See p. 250, Vol. XVII., "Scientific American."

Now, let us see if the plea of low water, a cause always plausible to its advocates, can be advanced in this case. The boiler contained about 1,300 gals., or 10,875 lbs. of water, and about the same quantity, 174 cubic ft., of steam. The pressure intended to operate the safety valve was 60 lbs. per in. Supposing the pressure to have been up to this maximum, the stored available power for destruction, allowing no stored up heat in the water above that due to its pressure, would be about 56,500,000 ft. lbs.*

This force, after the boiler once gave way, was exerted and spent in every direction, and included the part expended in tearing the boiler. Therefore, scarcely 25 per cent. of it, or about 14 millions ft. lbs. could have been active in propelling the boiler into the air. The height to which it arose is indicated by its "nearly vertical" ascension, together with the base of the parabola forming its path—450 ft., and by its appearance in the air, "about the size of a nail-keg,—(its size 14 ft. high, 7 ft. average diameter). Assuming the altitude at four times the base of the parabola, the former would be about $\frac{1}{3}$ of a mile. This would indicate an initial velocity of the boiler of 336 ft. To allow for atmospheric resistance, 350 ft. is assumed. The boiler weighed 11,000 lbs., and would require $\frac{11000 \times 350^2}{64.32}$—or 21,000,000 ft. lbs., to give it that velocity. The boiler gave way at the upper head of the tube cylinder, where, owing to the construction of the boiler, steam would accumulate, and prevent contact of the water with the metal. This part was some 20 in. below the crown sheet, and about 3 ft. below the usual water level. Had the water been below that tube sheet, the boiler would have contained only about half the usual amount of water, and the total force developed would have been only about 28,000,000 ft. lbs., or only about 7,000,000 to propel the boiler, while a force of over 21,000,000 ft. lbs., seem to have been expended on the latter. The deficiency is still more striking, when the above remark is applied. "It was not doing more than about half its ordinary work," implying a low pressure.

These data are not very satisfactory, it is true. But there are points about these cases unmistakably indicating something more sudden than the normal formation of steam, however rapid, which can never result in a blow, that being the distinctive feature of an explosion as compared to a rupture. If it was a gradual overpressure that hurled these boilers into the air, why did they give way endways on both ends of the tube cylinder; why not sideways in the line of least resistance? The boiler of the Starbuck, with some 56 lbs. pressure, and plates in places not over $\frac{1}{64}$ of an in. thick, was only rent, the opening scarcely admitting a knife blade. Why did it not explode? What causes the appearance in parts of some exploded boilers as if a cannon ball had passed through?

The proposition that electricity and other atmospheric influences may have something to do with explosions, cannot contemptuously be cast aside. Faraday's and Armstrong's experiments show that electric sparks, from 1 to 2 ft. long (if I remember correctly), may be obtained from a small boiler while the steam is in motion. There is the significant fact, that with a trace of salt in the water, no such sparks can be obtained! Has this

* This quantity is only about ¼ of that arrived at by Nystrom's formula, which I do not consider correct in practice. The following calculation, given in accordance with the logic upon which the operation is based, will explain. The heat above 32 deg. F., in 10,875 lbs. of water at 60 lbs. pressure above the atmosphere is 3,025,600 units. At atmospheric pressure this water retains 1,968,400 units; and the balance of 1,157,200 units supply the latent heat to evaporate about 1,175 lbs. of that water. The first lb. evaporated will have a pressure of nearly 60+15 lbs., and the last lb. will be a little over atmospheric pressure. But the mean pressure is much below the average of the two, because the water, in losing a high pressure, does not surrender as much heat per pound as at lower pressures. The calculation is complex, although very interesting to those fond of this mental exercise. To make sure of arriving at an approximately correct average, I divided the range between 60+15 lbs. and atmospheric pressure into 12 parts, and calculated each part separately, to wit: The amount of heat surrendered by the water; the amount of water evaporated by it; the pressure and amount of steam thus obtained, and the work stored in it in expanding to atmospheric pressure. By this mode, the reasons for every step taken remain clear, and are easily followed to the end. From the result obtained, the actual work corresponding to one unit of heat, must be deducted for every 772 ft. lbs. of work obtained, because that much heat disappears, or rather is converted into work, and is, therefore, not available to continue expansion. The expansion of the 174 cubic ft. of steam gives out about 1,500,000 ft. lbs., less the deduction just named.

anything to do with the coincidence that the explosion of a boiler at sea (using salt water more or less) is something very rare, almost unheard of? John Wise says, as stated on p. 189, "Scientific American," March 19, 1870: "When I drop water on a hot plate, below a red heat, it rolls about without making noise or steam. When the spheroid is rolled over the edge of the hot plate on to one of lower temperature, it explodes. If, however, it be struck with a hammer while rolling about on the hot plate, *it goes off like a fulminate*, resembling the crepitating noise of thunder, as heard by an observer immediately above the cloud in which it occurs." Mr. Wise thinks the phenomenon electrical, and as such, he thinks, violent explosions in connection with it are readily explained. Electrical phenomena are not all understood. Tyndall's remark, that he had not even a theory about magnetism is a very striking one, and applicable to other matter. I am in possession now of electrical phenomena, proved to be a reality, which no one has as yet been able to force even into a plausible theory.

In the face of all this, would it be wise to insist that nothing of the kind alleged in class D can occur, and that a strong boiler, with plenty of water and a good safety valve, is all sufficient? Sooner or later the Government may create a bureau of experiments which could remove doubt on these subjects, and save millions in property and thousands of lives, now destroyed by casualties caused by misapplying and ignoring the forces of nature. Such a bureau could disseminate, in a concise pamphlet form, the most necessary directions in the management of boilers, as prescribed instructions, to which might be added properly prepared blanks, upon which every engineer thus instructed, and interested in the matter, could (and most of them would) record any remarkable phenomena. These records, collected periodically, and the data thus obtained properly tabulated, would serve to improve steam engineering in general, and would lead to the discovery of phenomena having a disturbing influence upon boilers.

In the meantime, what shall be done? To admit that explosions are caused by other agencies than gradual over-pressure, does not in the least detract from the vigilance required to preserve the direct capacity of resistance of a boiler. But on the other hand, to ignore these other causes, let them be doubted ever so much, would seem as logical as to treat a purported keg of sand, as to which some doubt exists, whether it may not be a keg of powder, with as little protection against ignition, as a keg of sand would require.

Does circulation in the least degree decrease the power of resistance of a boiler?

Is not circulation the best agent for rapid formation of steam, and best possible protection against overheating of metal from any cause, in fact the preeminent requirement in a good boiler, without regard to explosion? It may be applied in a variety of ways. By mechanical means through power; by automatic means. By the constant pumping in of some air with feed water or separately. And especially by constant feeding, or at least constant when the engine is not in operation. The circulation caused by the feed water, however, is not sufficient under all circumstances.

It has been seriously proposed to discard the hydrostatic test. The question arises, why discard it? and what is to be substituted in its place? The proposition is here made, that such a test properly made, is perfectly reliable. All authors on the limit of elasticity of iron, or, in other words, the limit to which it may be strained without injuring its power of resistance, place that limit above two-fifths of the breaking resistance. If, therefore, a boiler is tested to one-third of its ultimate strength, no injury can be done. The working pressure should be half that. The special purpose of the test is to ascertain whether the assumed or calculated power of resistance really exists. For example, judging by the construction, materials, etc., a boiler is assumed to be able to stand with perfect safety, say a working pressure of 25 lbs. It is tested at 50 lbs. Merely to get up that pressure for a minute or so, would prove nothing; it might, in fact, injure the boiler so as to burst with a lower pressure. But if the 50 lbs. can be kept up with a slight and *steady* feeding by the pump (to make up for slight weeping of the boiler)—say for an hour, without any sudden giving way or sinking of the pressure, and without requiring irregularities in the feeding up—the boiler has not been injured by the test, and is safe at half that as a working pressure. This course should be pursued

whether the boiler be new or old. It is difficult to conceive on what ground an old boiler should be tested on less than double the working pressure, if that is made the rule for a new one.

Let an inspector receive an ample salary, and forfeit a heavy amount, retained from his salary, for every explosion of a boiler by him certified to as in order. The majority, it is hoped, will do their full duty without any extra incentive. They will nevertheless not object to the higher salary, with the risk (if any), as giving a greater feeling of security to the people. There is another class, however, whom nature has not constituted cautious, and with whom recklessness, even when their own lives are concerned, cannot be shaken off. These are not fit for inspectors under any circumstances.

STRAINS IN TRUSSES.—No. IV.

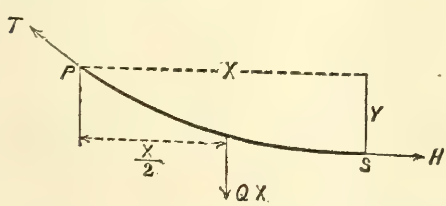
THEORY OF PARABOLIC GIRDERS.

It has already been shown that the strains in a parabolic girder may be found by the method of static moments, without knowledge of the usual theory applicable to such a girder.

Two peculiarities were discovered by this method: that under full load the strains in horizontal members are at the maximum and are equal; and that under full load, the strains in diagonals are zero. The second principle is a corollary of the first, for if $X = X_1$ (horizontal strains), then any diagonal strain Y must be zero.

It will be useful to determine upon what conditions these properties depend. A knowledge of them is necessary, not only to find the strains in a given girder, but also to determine the form adapted to given strains.

Suppose a chain fixed at two points A and B, hanging in equilibrium, and with its weight uniformly distributed along its horizontal span, the unit weight being q. Suppose the chain to be cut at the lowest point S, where the strain is horizontal, and that the chain is kept in the same position by a force H. This must be horizontal in direction, otherwise it would pull the ends out of their position. Suppose the chain cut at another point P, and that equilibrium is maintained by a force T.



The piece S P (Fig 1.) is kept in equilibrium by 3 forces, H, T, and the resultant of the weights distributed along S P. This last force is $q\,x$; x being horizontal distance between S and P. It acts at the distance $\frac{x}{2}$ from either end, the load being uniformly distributed.

The equation of moments, P being the centre of moments, is

$$(1) \qquad H\,y = q\,x\,\frac{x}{2}$$

As the point P is arbitrary, this equations holds for all points, *e. g.*, for A, where $x = l$ and $y = f$; l being the half-span, and f the depth at centre.

$$(2) \qquad H f = q\,l\,\frac{l}{2}$$

Dividing (1) by (2) we have

$$(3) \qquad \frac{y}{f} = \frac{x^2}{l^2}$$

The same conditions hold for the section S B. By means of equation (3) the position of various points may be found by substituting for x given values and solving the equation for y. These points lie in a parabola, the form of which depends upon the magnitudes of f and l.

The following principles are deduced from the above investigation:

First.—The horizontal strain produced by T is equal to H at all points, and is therefore equal at A and B.

Second.—The vertical component of T is $q\,x$; and at the points of suspension is $q\,l$.

Third.—The tension T is equal to

$$\sqrt{H^2 + V^2}.$$

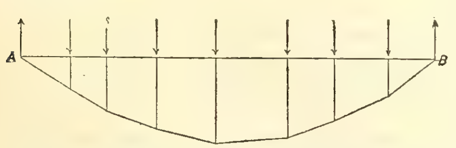
It follows that any particular points of the chain will remain in the parabola, if they receive loads which will satisfy equa-

tions (1) and (2). This happens when the loads are concentrated at points on both sides of S, so that each point bears the $\frac{1}{2}$ of each adjacent section. For the whole load on the section S P is still $q\,x$, and its lever arm $\frac{x}{2}$, as the centre of gravity, remains at the middle. Such a condition may be caused by verticals which transfer the strains of the load to the supporting chain. As the unloaded portion of a stretched chain is rectilinear, the whole length takes the form of a polygon inscribed in a parabola. This is the case even if the vertex S is not loaded. For suppose any piece to be cut out and that equilibrium is maintained by the forces T, T_1; then, that there may be no turning about P, we must have

$$T_1\,t = q\,x\frac{x}{2},$$

t being the lever arm of T_1; and it is easily shown that the same form of equation would hold for any other section supposed cut out.

If the two points A and B receive vertical resistances only, both the horizontal forces H must be represented by the reactions of a horizontal piece fixed between the abutments, which may be regarded as composed of several pieces. This gives a parabolic girder of the form represented in Fig. 2, which is capable of supporting a uniformly distributed load without diagonals.



The condition that a girder have the required properties may be expressed as follows:

The points of support of vertical members must lie in a parabola whose axis coincides with the central vertical line of the construction.

The above results are applicable in the case when the forces act in opposite directions; the convexity of the parabola being taken upwards.

The Camden and Amboy Railroad has not yet passed under the control of its lessees, the Pennsylvania Railroad Company.

From the "Manufacturer and Builder," we learn that the ingenuity of the American mechanic has found an eccentric interpreter in W. I. Trafton, of Manchester, N. H., who is making the smallest possible specimen of an engine. Every part of it is constructed out of a silver half-dollar. The boiler is to hold about 8 drops of water, but with 4 drops the engine can be worked several minutes. When finished, it is to be placed under a glass case $\frac{3}{4}$ in. in diameter, and $1\frac{1}{8}$ in. in height. Some of the parts will be so fine and delicate that they cannot be made without the use of a magnifying glass.

According to the "Food Journal," New York is beginning to feel the influence of the completion of the Pacific Railway. Formerly teas were imported *via* the Isthmus of Panama, but now this route is superseded by the shipments forwarded from San Francisco by the new overland line. If the railway freight is not too heavy, New York can thus be more cheaply supplied than by sea, while the qualities will be fresher and altogether superior. The ultimate effect will be that New York will not only be converted from an import to an export trading station, but that all the teas, silks, and other Asiatic products will be forwarded through it for the supply of Europe.

Mr. Proctor is engaged in the construction of an isographic chart of the northern heavens, in which are to be included all the stars (324,000 in number) of Argelander's noble series of charts. Mr. Proctor's object in charting these stars on a single sheet is to endeavor to ascertain what laws of distribution exist among the stars of the first 9 or 10 orders of magnitude. Struve has already examined a portion of the same list of stars with a somewhat similar object; but as he dealt only with numerical relations, and these relating only to averages, it seems not unlikely that the presentation of all the 324,000 stars in a single view, all the details of their arrangement being preserved, may lead to results of extreme interest.

STRENGTH OF IRON TUBES.

From "The Engineer."

So long as any structure of either an engineering or architectural character retains its form under the ordinary conditions of the load it is intended to carry, or undergoes only such an alteration in its normal shape as is consistent with its design, so long may it be regarded as secure, and equal to the duty imposed upon it. But directly the relative position of its several parts becomes changed so as to exceed this limit, then there is danger of its downfall taking place. Hence it is not sufficient in designing an iron bridge or roof, that the respective members of it should be adequately proportioned to resist the strains to which they will be subjected, as it is essential that provision should be made that they should always be in a position to perform that duty. The difficulty of insuring this constant feature in structures increases in a very high ratio with the dimensions and complexity of the design. The tendency to deformation—by which term is understood any alteration from the normal shape—augments considerably with the number of individual parts and the separate connections that are present. Hence, to guard against deformation has always been one of the principal difficulties which engineers have had to contend with, especially since the employment of iron on a large scale for works of construction. If a solid beam deflect beyond a certain limit, or if a wall bulge outwards or inwards too much, the eye, aided by a little common sense, will perceive the danger; but in structures of a more complicated description the evil is not detected in so simple a manner. A, comparatively speaking, very slight deformamation in a compound trussed girder, for example, will suffice to disarrange the accurate adjustment of the strains, and by bringing members of the truss into compression which would otherwise be in extension, and *vice versa*, seriously jeopardize the stability of the structure. So long as the dimensions of bridges and roofs remained small, there existed but little risk, as the quantity of material superfluously introduced was more than sufficient to leave a margin of safety which under no possible circumstance could be exceeded. But this method of getting on the safe side of danger was no longer admissible when the structures assumed what were once considered gigantic proportions; and more scientific and precise means had to be adopted to meet the requirements of cases that presented themselves.

It is, no doubt, within the memory of our readers that the two great dangers the promoters of the Britannia Bridge over the Menai Straits had to dread, were the imagined force of the wind against the sides of the tubes, and the alleged probable deformation of the top and bottom, more particularly the former of these two. To say that fears on these grounds were altogether groundless would be as false to assert as that the dangers possessed the magnitude imagined. One result of them was that experiments were instituted with the view of investigating the comparative value of different sections of tubular girders, or, more strictly speaking, of tubes proper. These are deserving of much attention, inasmuch as it is very doubtful whether the rectangular form is theoretically or practically the best to adopt in cases similar to that of the Britannia Bridge. This question is of more significance at the present time, because we are in possession of additional information respecting the other forms of tubes which was not at our command then. But, omitting all consideration of this, there were sufficient data at hand at the time of the carrying on of the experiments relative to the Menai Bridge, to warrant a more extended investigation into the merits of the cylindrical and elliptical sections. Although the idea of employing cast iron as the material for a bridge across the Straits was speedily abandoned by Stephenson, in consequence of the opposition displayed by the Admiralty and other parties interested in the navigation, yet the question of the relative strength of cast-iron tubes of different sections was submitted to actual experiment. A certain number of square, round, oval, and rectangular tubes were subjected to a direct breaking weight, and the separate results carefully compared. In experiments of this character,

in which the object aimed at is the determination of the best form of section in which to utilize a material, it is essential, in order to avoid complicated calculations, that the quantity of material should be the same in all the sections experimented upon. Thus, in the instance alluded to, the tubes were all of the same thickness, although the depth and width necessarily varied. There was very little difference between the strength of the square, round, and rectangular tubes, but the increase of depth in the oval example at once gave it a great advantage over the other forms. With the same amount of material, and consequently with the same weight, the oval tube showed an increase of strength amounting to nearly 50 per cent. above the other sections. But this result must not be regarded as proof that the elliptically shaped section is absolutely the best form to resist a transverse strain under all conditions of proportion and distribution of material. If the element of depth be eliminated from the calculation, or what amounts to the same, if the depth and sectional area be common to all, then the square tube will afford the greatest resistance. The square is therefore, *per se*, the strongest form, since, the depth being the same, it derives no special advantage from that important dimension over and above that enjoyed by the other forms. Consequently the superior result is due solely to its particular shape, but there are practical reasons for giving the preference to the round tube in all ordinary applications of the material in a hollow form.

It is admitted now that the experiments carried on at the time of the building of the Britannia Bridge, with respect to the strength of wrought-iron tubes of different shaped sections, were very incomplete, and also that the conclusions arrived at regarding the powers of resistance of the circular and elliptical forms were premature. The fact is, that the fear of deformation led to a too hasty abandonment of these two forms. Under the strains to which they were subjected the circular and elliptical forms soon became distorted ; but had care been taken to prevent deformation taking place, there is no doubt the results would have been highly satisfactory. The effect of placing a load upon a circular or oval shaped tube would obviously be to convert the one into an ellipse, and make the other still more elliptical. It is easy to perceive the evil of this. In their normal condition under a load one portion is strained compressively and the other tensilely, but directly deformation occurs this equable distribution of strain no longer prevails. Parts that were in compression became strained in tension, and instead of the top and bottom flanges maintaining their respective distances unaltered from the neutral axis, their relative position was changed, and they performed, more or less, according to the amount of elongation produced, the functions of the web of a girder. Bearin mind the extreme thinness of the tubes, and the absence of all diaphragms, it is obvious that no other result could have been expected. The only precaution taken to prevent deformation was the introduction of wooden blocks in the interior of the tubes over the bearings where the shearing strain reaches a maximum. This precaution is still used in the designing of large girders of either the plate or lattice type, in which the web is invariably strengthened at these points by additional bars and stiffening pieces. In order to effect the same purpose, and increase the rigidity of the structure, it is not an uncommon practice of the French engineers to construct the ends of lattice and open web girders of solid plates. But the best guarantee against the alteration of form in flanges of girders lies in using thick plates, which is the true remedy for buckling. Had thick plates been employed in these experimental tubes, together with a suitable number of diaphragms, the preference might not, perhaps, have been given so unreservedly to the rectangular form of section. The results cannot be considered as a fair criterion of the strength of circular and elliptical tubes, more especially when it is borne in mind that the riveting was of a most inferior description. It is not necessary to investigate the reasons, which were chiefly of a practical nature, that finally led to the adoption of the rectangular section, but it cannot be overlooked that the experiments which were conducted with relation to tubes of that form were as complete and extended as it was possible to make them. Had the same course been adopt-

ed with respect to those of the circular and elliptical form, the fear of deformation would have been soon shown to be groundless, and the superiority of the latter section, in the matter of riveting, which would have been about $\frac{1}{4}$ of that required in the rectangular tube, would have become very apparent.

The experiments to which reference has been made, relate wholly to the transverse strength of tubes of cast and wrought iron, and have no bearing upon their resistance to longitudinal strains of tension and compression. In other words, a distinction must be made between a tube acting as a beam or girder in itself or in the position of one of the members of a girder. In the latter capacity both cast and wrought iron tubes of very considerable dimensions have been used. While in this position they are not subjected to any transverse strain, but merely resist the horizontal components of the shearing strains arising from the load. But whether they act in one or other of these situations, it is equally imperative to prevent alteration of form by the use of diaphragms. From the fact that cast iron must, for practical reasons, have a much greater thickness, when in the form of a tube, than wrought iron, it is evidently better adapted for the top flange of a large girder than the other material. In the former case the material itself, by virtue of its own thickness, presents a great resistance to any tendency to deformation. In the latter, the whole resistance must be provided for by the employment of additional and extraneous metal. Owing to the numerous accidents which have befallen compound structures in which cast and wrought iron have been employed in combination, there is a strong prejudice against this method of construction. On several occasions we have touched upon this subject, and observed that the greatest care and skill are requisite to insure that a design of this character shall be of a reliable and durable nature. It is not so much want of strength in cast iron as a material for construction, that limits its application in engineering works, as that it is difficult to obtain it in the best form of proper dimensions for works of magnitude.

LOCOMOTIVE ECONOMY.

From "Engineering."

It is not very many years since locomotive engines had to be reckoned amongst the most economical power producers in use. The high-pressure steam with which they have long been worked, their high piston speeds, and the generally good proportions of their boilers and valve gear, gave them, at the time to which we refer, great advantages over most of their competitors, and the consequence was, that, as we have said, the locomotive held in those days a high position amongst engines generally. At the present time, however, matters are greatly changed; high steam pressures and high piston speeds are no longer almost peculiar to locomotive practice, while the development of surface condensation and the compound system have combined to assist in the production of engines capable of developing a horse-power with a consumption of fuel amounting to less than $\frac{2}{3}$, probably, of that required in the best locomotive ever built. Even portable engines—long regarded with something not very different from contempt by railway engineers—have, under the fostering care of the Royal Agricultural Society, improved of late years to an extent which renders them, in a large number of instances, more than a match for the locomotive as far as economy of fuel is concerned; and only a few months ago we took occasion to point out that, in some respects, locomotive engineers might now advantageously adopt, with certain modifications, the practice of portable engine builders. Under these circumstances, it appears to us worth while to consider the causes which have contributed to this result, and to explain briefly some points connected with locomotive economy, which we have reason to believe are not so generally understood as they deserve to be.

We have, on former occasions, when writing on steam engine economy, always been careful to point out that the real value of any improvement applied to a

steam engine is dependent in a most important degree upon the nature of the work which that particular engine has to perform. We have shown that the greater the number of hours per annum that an engine is in steam, the greater is the expenditure which it is justifiable to incur to obtain a given percentage of reduction in the consumption of fuel, and *vice versâ ;* and we have explained how an improvement which, in one instance, might be adopted with considerable profit, would, if resorted to in another instance, actually cause a monetary loss. Now there is no class of engine to which these arguments apply with greater force than to a locomotive. The average number of hours per annum during which a locomotive is actually running is small, the average power developed when running is considerably below the maximum power which the engine is capable of developing, and hence, the total number of foot-pounds of work developed per annum and the total cost of fuel per annum are both very small in proportion to the cost of the machine. How small this annual cost of fuel per locomotive really is, is probably known to but few beyond those specially concerned in railway management, and we therefore subjoin a table containing some data on this point, which we believe will be interesting. The figures given in this table, we may remark, have been calculated from the returns of ten of our principal railway companies for the last six months of the past year, the "average cost of fuel per engine per half year" being obtained simply by dividing, in each case, the total cost of coke and coal for the half year by the number of engines possessed by the Company.

NAME OF RAILWAY.	Average number of miles run per engine during half year.	Average cost of fuel per engine per half year.
London and North-Western	8,140	£48 19 4
Great Western	8,833	52 17 5
North-Eastern	9,141	83 11 8
Midland	10,740	79 0 0
Great Northern	9,795	67 12 9
Great Eastern	9,797	73 2 3
South-Eastern	8,334	108 0 0
London, Brighton and South Coast	9,961	138 4 11
London and South-Western	12,093	111 19 3
London, Chatham and Dover	10,221	131 0 11
Means of above for half year	9,705½	£89 8 10
Means per engine per annum	19,411	£178 17 8

In round numbers we may call the average cost of fuel per engine per annum £180, and if we take the mean gross cost of an engine as £2,400, we see that the cost of fuel really amounts to an annual charge of but 7½ per cent. on the cost of the machine. In other words, if it were possible, by doubling the cost of construction, to render a locomotive capable of doing its work without any fuel whatever, the saving would, on the average, only pay interest at the rate of 7½ per cent. on the extra outlay, even if we suppose that this outlay involved no increase in the allowance to be made for depreciation. In the case of the London and North-Western Railway, moreover, the interest on the additional outlay, under the circumstances above supposed, would amount to but 4 per cent., a very unremunerative result. In the above instances we have supposed, as we have said, that an extra outlay on the engine involved no extra charges for depreciation; but in reality this, of course, would not be the case. There are, probably, extremely few improvements which are capable of being applied to a locomotive for the purpose of obtaining greater economy of fuel, which will not render necessary an additional allowance for depreciation fully proportional to the increase they cause in the cost of the engine, and if we take this charge for depreciation as 10 per cent., and the interest on extra capital invested as 5 per cent., we shall have a total annual charge of 15 per cent. on the cost of any such improvement as we have sup-

posed, which must be cleared off before the use of the improvement results in a profit. Let us, for instance, suppose a locomotive to be fitted with some fuel-saving arrangements involving an additional cost of £200 ; then these arrangements would have to save per annum a sufficient amount of fuel to pay an annual charge of £30 (£20 for depreciation and £10 for interest) before the use of these additional appliances was attended with any profit to the railway company to which the locomotive belonged. But £30 is about $\frac{1}{6}$ of the average total annual expenditure for fuel, and therefore, fuel-saving arrangements, such as we have just supposed to be applied, would have to effect a reduction in the consumption of fuel of at least $16\frac{1}{2}$ per cent. in order to avoid their use being attended with an absolute loss. In the case of the London and North-Western Railway, where the average cost of fuel per engine per annum is less than £100, the £30 above mentioned would represent the cost of rather more than 30 per cent. of the annual consumption of fuel, and the fuel-saving appliances costing £200 would, therefore, have to reduce the consumption more than 30 per cent. before they became profitable.

Assuming that the above-mentioned allowance for depreciation is fairly correct, and making a slight additional allowance for incidental expenses mostly attendant upon the employment of additional parts on an engine, we may consider broadly that any fuel-saving appliances added to a locomotive must, to avoid their use being attended with loss, effect on the average a reduction of fuel amounting to 1 per cent. for each £10 of their original cost. Now, with this fact before us, it is easy to understand why simplicity has always been regarded as a cardinal virtue in a locomotive, and why so few "refinements" have ever been found profitable when applied to it. Notwithstanding this, however, there are a few fuel-saving appliances which, although involving some additional cost, might certainly be very generally employed with advantage. The most important of these are steam jackets for the cylinders, and a simple arrangement of feed-water heater. With the increased pressures of steam now in use, steam jackets are more than ever a necessity for economical expansive working, and we have on a former occasion pointed out how they may be very readily applied to locomotives. Feed-water heaters are, we are glad to say, coming into use on several lines, and we hope to see their employment extended.

So far, in speaking of locomotive economy, we have considered an engine merely as a power-producing machine ; but in reality a locomotive is far more than this. Besides being a steam engine proper, it is a carriage on which the engine and the stores of fuel and water for working that engine can be transported from place to place, and this carriage portion of the machine exercises a most important influence upon the question of maintenance. Speaking in general terms, the average total expenditure per locomotive per annum on our main lines of railway may be taken as about £660, this sum being divided out about as follows :

Fuel	28 per cent.
Wages and other running expenses	32 "
Repairs and renewals	35 "
General charges	5 "
	100

Now if we still assume the average value of a locomotive to be £2,400, we shall see that the mere annual charge for interest on this sum taken at 5 per cent. will amount to $\frac{1}{5}$ of the whole annual expense of working and maintenance, or, in other words, that it will be nearly equal to the whole cost of repairs and renewals. If now, by any modification or improvement in construction, we suppose it possible, without increasing the cost, to make one engine do the work which it at present requires two to perform, there would at once be effected a saving, due merely to the reduction of interest charge, equal to that which would be obtained by reducing the consumption of fuel to $\frac{2}{3}$ of its present amount, while there would be the further advantage that the saving resulting from any given improvement in the economical production and use of the steam would be proportionately increased. It is here that we have the key to the true method of securing locomotive economy, and an explanation of the fact that the most successful locomotive superintendents have been those who have paid the greatest attention to the production of a thoroughly durable engine at a moderate cost. It is thus that locomotive engineers have of late years thrown themselves open to the charge of paying more attention to what

may be termed locomotive manufacture, than to the development of the engine as an economical steam user; but a careful consideration of the facts of the case shows that in doing this they have been consulting the best interests of those for whom they act. The greatest aids to locomotive economy are, in fact, such improvements in construction as enable the engines to be worked for long periods without entering the shops for repairs, and such arrangements as enable the engines to run a large annual mileage, without, however, interfering with the proper intervals for cleaning and general overhauling. In fact, so long as the latter points are attended to, the harder locomotives are worked the better will be the economical results. It is impossible, within the scope of the present notice, to do more than direct attention to the general principles we have endeavored to explain, but we intend in future articles to speak of some of the leading points of detail upon which locomotive economy in a great measure depends.

THE CATHEDRAL OF COLOGNE.

From "The Building News."

The double work of restoring and completing this splendid structure goes on, we regret to learn, but slowly. From recent numbers of the "Domblatt," or "Cathedral Leaf," a journal expressly devoted to this one subject, and which empties all its profits into the subscription box, we learn that scarcely any stone was put in, scarcely any money collected, scarcely any work done last year. That, however, need not be a subject of surprise. War and preparations for war do not belong to the harvest times of art in any country; and the mighty shrine of Cologne naturally stood neglected while diplomacy first, and battles afterwards, absorbed the anxieties of Europe. But it is nothing less than marvellous that the Germans—a people of so much national pride—should exhibit apathy, and even parsimony, in respect of their magnificient temple—the crown of all Gothic in continental Europe. Yet so it is. A destiny would almost appear to hang about the building, as though it would never be finished, and as though while the new sprung up the old were foredoomed to decay. We have to remember, in fact, that this is the process actually going on. Month by month, as the central tower of iron rose from its 4 sustaining pillars, deep-rooted in the earth, through the roof and up, in perfect grace and lightness, to a stately and airy height, the grand portico was literally mouldering, and dropping in minute fragments to the ground. The fault lay with the original constructors, who quarried for their stone in the soft and porous cliffs of the Seven Mountains, and, more particularly, among the friable strata of the Drachenfels. Materials of that kind were not calculated to endure for ages, as is testified to by the incessant patchings which the robber knights and feudal princes of the Rhine had to bestow upon their castles, and the rapid crumbling of these edifices after being once abandoned by those who had an interest in preserving them. In fact, were it not for the tourists, who supply an incentive to the conservators guarding the picturesqueness of the Fatherland river, the ruins themselves would speedily be ruined, and sink down in shapeless masses on the rocks. This cause partly accounts for the dilapidation of the incomparable Cathedral which adorns, even in its incompleteness, the most important city of Rhenish Prussia—a province overwhelming with wealth, though begrudging the cost of terminating that task which artists and monarchs gloried to contemplate 6 centuries ago. It is disheartening even for the stranger, who cannot be supposed to share the German pride in this sumptuous trophy of time, to revisit the City of the Three Kings; to revisit, autumn after autumn, and perceive the same melancholy signs of indifference and lassitude—the paltry heaps of unhewn stone, from Andernach and Treves, on the terrace; the sawing and sculpturing yard, unworthy of a third-rate Thames-side contractor; the meagre scaffolding; the few stragglers on the roof; and, above all, the inferior, rough, spiritless, characterless work employed. Within there is an appearance, but only an

appearance, of greater activity. That is to say, the perspective is ruined, as it has been for years past, by forests and frames of timber ; and the wondrous beauty of the choir is threatened with the heavy touch of 19th-century restoration, when it needs no touch whatever, except for the replacing of certain fallen fragments. But a fragment takes a long time to replace in the Cathedral of Cologne. On October 17th, 1434, one of the pinnacles of the gallery running round the vault above the Chapel of the Magi fell down. On October 17th, 1834, 400 years later exactly, it was restored. That is about the rate at which things do move in the capital of the Eleven Thousand Virgins. Passing through the portal, the sculptured beauties of which are rapidly exfoliating themselves out of form, we glance up, as far as may be, through the twilight interiors of the towers, which are to be 500 ft. high, and have not risen a foot for centuries past. They are choked with scaffolding, and not the sound of a hammer, or a chisel, or a trowel, or a man's voice, is heard. You inquire of the sacristan, "When are the workmen here?" "They will be here when there is money to pay them." You may easily believe it. The "Cathedral Gazette" announces the week's subscription,to the fund for carrying on this universal German labor of love—they amount, perhaps to 10s. 6d.! and this is no exaggeration. It is clear that the heart of Germany is not in the giant Dom of Cologne. A quarter of a century has elapsed since a prodigious noise was made, calling upon the entire Fatherland to rescue its proudest monument from the wasting influences which were reducing it to the skeleton of its former self. It had gone on growing through generations. The plans of its unknown architect were taken up—a bit added here and a bit there—and laid aside again. In one reign a few statues were installed in their niches; in another a painted window threw its gilded and jewelled light upon the fractured floor, making it all one treasure ; in a third a patch was put on the roof, or a figure graven for a tomb, to catch the same ruddy and amber rays athwart some saintly face. But at length, 50 years ago, the Germans began to profess themselves ashamed of the sight that was to be seen in the opulent city of Cologne. *Reich wie ein Köllner*—rich as a Cologner—had long been a popular saying. The spectacle was, indeed, to be lamented. Much of the interior was only sheltered by a wooden roof ; the side aisles were not vaulted in ; the two great gables of the north and south front were fragments, though fragments of superb designs, surmounting every other stone structure in the city ; a part even of the exterior wall was wanting ; only a few of the buttresses stood firm ; the nave had to be reroofed and vaulted ; the cross gallery, with its pinnacles and gablets all lovingly indicated in the plans of the unknown architect, had never been erected ; of the parts that had been finished the finer traceries and mouldings were disappearing in decay ; the exterior sculpture exhibited signs of honeycomb ; total destruction, indeed, seemed to impend over the finest structure in Germany, even before it stood as a completed edifice at all. When the architects were called in they reported a degree of unsoundness, ricketiness, and dilapidation by thieves, who had stolen the leaden roofs, besides robbing the altars, that an immediate expenditure of £30,000 was necessary to prop the tottering parts. But the unknown architect was a Titan in his ideas, and what he built of the towers—unsunk and unshaken now—were really intended to bear, and can bear still, the weight of an additional 300 ft., ponderous and massive, which he contemplated rearing upon the 200 ft. already erect, huge, upright, unshaken by time and tempest, solid as rocks—the protectors of that glorious portal beneath whose arch many a noble church might stand, with plenty of place above the spire.

The German Governments, or rather those of Prussia, Wurtemberg, and Bavaria, at last felt compelled, for the honor of a nation which is nothing if not boastful, and has many reasons for boasting, to meditate upon a systematic plan for saving the Cathedral. Little importance can be attached to their resolves, however, until the year 1842 was reached. Then was constructed the machinery which, feebly and spasmodically, is still at work. King Frederick William IV. became a patron, and laid a new foundation-stone, as though the labors of 400 years were beginning over again ; and the Dombau-verein, or Cathedral Union, with 1,000

affiliated smaller unions ramifying through the land, was established. It was agreed, in a moment of unmeasured enthusiasm, that Cologne Cathedral should be regarded as a symbol of German unity. By the introduction of this political idea the progress of the task was retarded. Only Munich and Wurtemberg, where German unity is yet scarcely recognized, contributed generous subsidies. But the eagerness of the people was kept up at white heat for a time. The King put himself down for an annual subscription of £1,500 ; the societies collected funds ; lectures, sermons, festivals, were drawn upon as so many sources of help ; strangers were pitilessly sentinelled until they dropped money into the boxes padlocked on every door ; and, when nearly 20 years had elapsed, results were visible. Among others, 1,000,000 of thalers, or 1,000,000 of coins worth 3s. apiece, had been spent. The choir was finished, and its harmony slightly marred. The columns of the nave had been carried up to their destined height, with a less flagrant departure than might have been expected from the original design. The vaulting of the roof was in a fair way towards completion. The 200 ft. of tower had been surveyed, and pronounced not less solidly set in the earth than Ehrenbreitstein itself, and the "Domblatt" had commenced its appeals to the entire Catholic world to aid in the holy triumph at Cologne. But one singular influence was hostile to the Cathedal Union and the Cathedral "Leaf." It is a proverb throughout Rhenish Prussia, and far beyond it, that Cologne Cathedral will never be completed, though, in order to the fulfilment of this prediction it was not necessary to leave it as Napoleon's General found it when he, without the least irony, complimented the inhabitants of the city upon their "magnificent Gothic ruins." Still the laborers were not altogether idle. They declared, 8 years ago, that the interior only wanted a finishing touch. It wants a good many, at any rate, now. It is true that the barbarous partition separating the choir from the nave has at length been removed, so as to afford the hope of an unbroken perspective before long ; and even that every now and then, as if by magic, all the inside scaffolding disappears, when grand ceremonies have to be performed ; but a pilgrimage through the splendid spaces, and still more splendid recesses, of this surpassing edifice, proves that no part of it can yet be called perfect, unless it be the genius that lives in the whole. Nor need we wonder. With all the hubbub, the celebrations, the songs, the appeals, the local organizations, the patronage of princes, the mendicant missions abroad, the countenance of the Pontiff, the pride professed by Germany, and the periodical exaltations of the "Domblatt," we doubt whether any sum approaching to £750,000 sterling English has been expended upon the work from first to last, notwithstanding that the structure was to be adopted as a symbol of German greatness and unity. One thing, however, the restoring architects did accomplish 3 years ago, and every German, whether or not he had or had not subscribed to the Cathedral Restoration and Completion Fund, anticipated that, forthwith, the towers would rise to their predetermined loftiness of 500 ft. above the mound in the Marz Plaz, whereon, tradition records, Agrippina's Roman veterans encamped. They hauled down, in 1868, the ancient and remarkable crane on the south tower, which, for centuries, had been a landmark of the crescent-shaped city, especially from the river. They might have left it until there was masonry to put in its place. Many a tourist, wearying his eye for the Cathedral, first caught sight of the old, well-known, black crane, with its grotesque framework and its beam slanting upwards like a bowsprit. It has disappeared, and, let us hope, is in some museum, for it was probably the only genuine specimen extant of the cranes employed by the builders of the middle ages. That its power was immense is demonstrated by the masses of stone which it must have lifted ; but, among all the florid histories of the Cathedral with which German hand-book literature abounds, we have met with no description of its mechanical principles. As for Schlegel. he, of course, regarded it as no part of his subject, and so soared from the crane into the entities. After their war, however, and the accomplishment of their unity, of which, despite prophecy, the Cologne Dom was not to be a symbol, we may hope for more rapid advances. For the sake of the choir and the majestic south portal alone, if not for the sublime

design of the towers and the luxury of art-thoughts which must have been amassed in the mind of the architect when he traced those aspiring pillars, those wondrous flying buttresses, those giant piers, that dream of purpled pinnacles, and those casket-like chapels which are jewels holding gems. But, it must be repeated, while the new is created the old is perishing, and the old means that which was truest to the typical hope of the founder. For, anxious and conscientious as the first generation of toilers may be, they devote themselves to their Cathedral in an inevitably modern spirit. It is not to them a passion which they yearn to perpetuate by a monument; they labor upon lifeless stone, that refuses to become animate beneath their hands. It is not the pious Parnassus of their ambition ; it is little sacred, little loved, little revered ; it is the world-renowned Cathedral of Cologne, which really must be finished, or it will grow into a scandal. These considerations, forcing themselves upon us, do not justify very exalted hopes. It may even be imagined that the Dom, the ancient of ages, would have been more beautiful and more hallowed as a ruin than it will be when the thrifty German people have counted out thalers sufficient for its completion. Nevertheless, Germany is doing right in attempting, with, however, half a heart, to prevent any such catastrophe ; for though it might not impair the splendor of the shrine in the eyes of those for whom every Basilica upon earth is a shrine, the disgrace to the nation must have been indelible. What inspirations of different times, what labor of numberless hands, what emulations of artists, what struggles against the effects of decay and ravage, do these ascending piles, raised upon such deep foundations, as though the architect had dreamed of immortality for them also, represent. They may be somewhat vulgarized by 19th-century contracts and repairs ; yet, taken for all in all, it is better that a people pretending to greatness should be careful of its sacred monuments, however tardily or slowly, especially when they assume such forms of religious grandeur as Cologne Cathedral, than that they should only admire them as they crumble, and dedicate their purses to the extinction of the arts—a project which is among the latest ebullitions of the Teutonic philosophy. So far for the story of a German architectural "restoration," not yet half on its way to be finished.

RAILWAYS IN CEYLON.

From "The Engineer."

In every instance in which the conveyance of goods alone is the object in view, and time not a question of primary importance, it will be admitted that carriage by water surpasses in cheapness all other known means of transport. To some extent, therefore, it becomes in colonies and undeveloped countries in which facilities for water communication exist, a matter for serious consideration whether those facilities should be improved and extended or practically nullified by the introduction of steam locomotion. It may perhaps be considered that we are going too far in tacitly assuming that the existence of the one description of transport must necessarily involve the extinction of the other. In England and in many other countries the railways and the canals can be seen running almost in parallel contiguity, and there is, if not abundance of work for both, at any rate sufficient to keep them both alive. But there is a vast difference between these instances and that of a young colony or semi-civilized nation, whose wealth consists in land alone, which, until cultivated superficially or explored subterraneously, is worth absolutely nothing. A new country cannot afford two different systems of communication ; it has only traffic for one, and, judging from the results at our command, the preference appears to be given to railways. This is the case even under circumstances in which we might expect the reverse, that is, in districts which are in possession of extensive water communication, which is as much needed for the conveyance of traffic as for the more important purposes of irrigation. It is evident that the same canal cannot well answer for both of these ob-

jects. In the event of a severe drought, in which the supply might be only adequate for one of the purposes, which is to give way, the irrigation or the traffic, and where is compensation to come from for the sufferer? The real reason for the construction of railways in preference to canals is to be found in the character of the districts through which they pass. The mineral wealth of a country rarely lies in the plains; it must be sought for in the mountains, in the regions of gorges and ravines, and in almost inaccessible localities where it is difficult to make a pathway, to say nothing of a railway. Some examples of lines constructed under these difficulties on a comparatively small scale can be witnessed at home, but they sink into insignificance before similar examples in America, the Brazils, India, Ceylon, the Mauritius, and other countries, where the physical obstacles to the construction of railways may be truly termed gigantic.

It is now nearly 4 years since the line was opened from Colombo to Kandy in Ceylon, an island which, by reason of its rugged contours, presents formidable impediments to the advent of the great pioneer of civilization. Although there is abundance of water power available in the island, yet, for the reason already mentioned the utilization of it as a means of transport was never entertained. Mountain torrents, until they are miles and miles distant from their source, cannot be converted into canals. Rather more than 20 years ago a company was formed for the construction of the line from Colombo to Kandy. A concession was sought from Government on the same principle which regulates the granting of similar powers in India, and after a delay of only 10 years it was obtained. As is usual on such occasions, previous to the ratification of the treaty an engineer was deputed on the part of the Government to make a reconnaissance of the country, and report whether in his opinion the line could be made for the sum guaranteed. The Secretary of State appointed the late Captain Moorsoom to undertake the task, who, with the aid of his assistants, examined 6 different routes, ultimately selecting one 80 miles in length, which he reported could be completed for the sum of £857,000, using round numbers. This sum included land, stations, works, permanent way, rolling stock, and all expenses and contingencies incidental to the putting into thorough working order a single line of road It is difficult to understand how any Government could imagine that the total expenses of a line and all its appurtenances, constructed in such a district, could be brought within the moderate sum of £11,000 per mile; but we have the authority of Mr. Molesworth that such was the case, that the concession was granted, and a staff of engineers sent out to survey and lay out the railway, with a view to its immediate progress. No sooner was the intended route definitely settled upon and subjected to a survey in detail than the fallacy of the statement respecting the cost became at once apparent. There are very few preliminary estimates that will stand the test of being worked out in actual practice, but the discrepancy will seldom or ever reach the amount of 100 per cent., as occurred in the case before us. After a full investigation of all the unavoidable difficulties in the shape of gradients, curves, and heavy works which beset the proposed route, the revised estimate attained the figure of £2,214,000. Notwithstanding this increased expenditure the line was of a very unfavorable character. Gradients of 1 in 16 were introduced, together with a stationary engine incline, 3 miles in length, and a couple of reversing stations. It would be scarcely possible to imagine a railway encumbered with features more objectionable. The accident that happened some time ago at the reversing station on a Ghaut in India is sufficient to demonstrate the great danger incurred in their adoption, and an incline worked by a stationary engine is a "trouble for ever."

So great a discrepancy as that which existed between the former and the latter estimates was sufficient to raise grave doubts in the minds of the authorities respecting the actual expenditure that would be required to make the line, and, losing confidence in their own advisers, they referred the whole matter to Mr. Robert Stephenson. The death of this gentleman prevented him carrying out the wishes of the Government, who then placed all the necessary data in the hands of Mr. Hawkshaw, and requested him to report upon the subject. After abolishing the stationary engine incline,

and introducing various modifications in the proposed route, Mr. Hawkshaw came to the conclusion that the total cost would, in all probability, not exceed £1,872,000. In the meantime, while these investigations and calculations were being carried on in England, Mr. Molesworth, who was the chief resident engineer in Ceylon, determined to ascertain whether a better route could not be obtained than that already proposed. As there was still a considerable staff of assistants in the island he employed them, with the concurrence of the Government, in making fresh surveys. The result justified his anticipations, and his exertions were rewarded with the success they deserved. The new line diminished the original distance by 5 miles, and reduced the gradients to so great an extent as to be equivalent to a pecuniary saving of £300,000. In spite of this satisfactory result, and the large expenditure incurred, the contract between the Company and the colony was dissolved by mutual consent, and in 1863 a contract was entered into by the Government with Mr. Faviell for the construction of the line in 4 years. The works would have, no doubt, been completed within the stipulated time but for the severe sickness that occurred in the unhealthy districts. An additional 8 months was accorded to the contractor, and a sum of £58,000 over and above the contract price, making the total cost of way and works to amount to £1,436,000, or a little over £19,000 per mile. The whole of the line has been constructed in a very efficient and durable manner, and the traffic returns which have been published in Mr. Molesworth's report are of the most encouraging character. There is one feature in connection with the estimates for railways in distant countries which deserves notice. It relates especially to the rolling stock, nearly all of which is of home manufacture, and shows that a margin should be always left for contingencies under this head. For some years the cost of work in England requiring skilled labor has been steadily on the increase. It is of little moment now to inquire into the cause, although one need not go far to find it. The lapse of nearly a couple of years was sufficient to produce a considerable rise in the price of the rolling stock exported to Ceylon. Locomotives sent out in 1867 cost £300 more than their predecessors, which were consigned to the Company 2 years previously. Carriages "rose" from £30 to £40 each, and there was a proportionate increase in the price of the inferior description of rolling stock, such as goods wagons, trucks, and other vehicles. When once a line has been regularly opened for traffic, the chief point is to keep the working expenses as low as possible, consistent with efficiency, during the first year or two, and in fact until the whole affair is brought into thorough good working trim the expenses afford no fair criterion of what they ought to be. Thus we find that for the first two years the line from Colombo to Kandy was worked at a loss. In the succeeding year the expenses averaged nearly 59 per cent. of the receipts, and subsequently were gradually reduced to 45, 40, and 36.

According to Pliny, there was no sun-dial in Rome until 11 years before the war with Pyrrhus, about 460 A. U. C., or nearly 300 years before Christ. They were known, however, to the Greeks 2 centuries earlier. The first seem to have been brought from Sicily to Rome, and Pliny complains that they did not suit the latitude, and gave the hours falsely. This evil was "diligently rectified" by a Roman mechanic; and the dial, in various forms, remained the only measure of time for a century and more. About 160 years before Christ, the *clepsydra*, or water clock, was introduced. This was similar in principle to our sand-glass. The water in a vessel was allowed gradually to escape. The first *clepsydræ* were not transparent, and probably they could only, like our hour-glass, mark a single division of time by the escape of all their contents. Subsequently, they were made of glass, and probably provided with graduated scales on which the lapse of the several hours could be perceived.

Many small basins of coal exist in the midst of the Rocky Mountains, not directly connected with the great coal-field along its eastern base, and it is considered likely that some of these basins contain anthracite coal.

THE DURATION OF THE ENGLISH COAL FIELDS.

From "The London Mining Journal."

The Report of the Commissioners appointed to inquire into the several matters relative to coal in the United Kingdom has just been issued. It contains a vast amount of information of the utmost possible utility and interest, and as the Commissioners decided at their first meeting to appoint committees to investigate separate subjects, they have been enabled to perform their duties very completely. The subjects intrusted to the five committees were, the possible depth in working, waste in combustion, waste in working, the probability of finding coal under the Permian, New Red Sandstone, and other superincumbent strata, and mineral statistics respectively. The Commissioners have had the advantage of paid assistance, and every facility seems to have been offered to them for collecting materials for their report, in the preparation of which the exertions of Mr. J. F. Campbell, the secretary, appear to have been most valuable.

The investigation to determine the maximum depth to which it would be possible to work coal has not been conclusive, but the Commissioners consider, from the evidence before them, that it might fairly be assumed that a depth of at least 4,000 ft. might be reached. This acknowledgment must give general satisfaction; for at present we have only about two mines that have reached one-half of that depth, and from the experience gained in those it appears that the high temperature is not in many cases permanent, and is frequently much modified by accidental circumstances. In this country the temperature of the earth is constant at a depth of about 50 ft., and at that depth the temperature is 50 deg. Fahr. The rate of increase in the coal districts is generally about 1 deg. Fahr. for every 60 ft. of depth. The heating process is most rapid at first, when the difference of temperature between the air and the strata is greatest, and gradually diminishes as the length of the passage is extended, never ceasing until complete assimilation of temperature. The air takes up the heat much more rapidly in pillar and stall working than in long-wall. The absorption of heat from the strata by the circulation of the air gradually lowers the temperature of a mine.

The labors of Committee C were directed to the inquiry whether there is reason to believe that coal is wasted by bad working or by carelessness, It seems that the extension of the long-wall system has diminished waste, but much is still lost by bad working and carelessness—a very considerable amount in proportion to that which is actually used. Under favorable systems of working, the loss is about 10 per cent., while in a very large number of instances the ordinary waste and loss amounts to 40 per cent.

With regard to the quantity of coal in known coal fields, it is estimated that within depths not exceeding 4,000 ft., and after making the necessary deductions, there are (including upwards of 130,000,000 tons in Ireland) 90,207,285,398 statute tons; while below 4,000 ft., there are 7,320,840,720 tons, making 97,528,126,210 tons in all, and in this estimate no consideration has been taken of any bed of coal less than 1 ft. in thickness. To this must be added a further quantity of 56,273,000,000 tons for the probable amount of coal under Permian and other overlying formations at depths of less than 4,000 ft., and, deducting 40 per cent. for contigencies, giving an aggregate of 146,480,000,000 tons. Estimating a gradual increase in the population, and that the consumption per head of population will attain its maximum at the end of the present century, a total consumption is shown of 146,736,000,000 tons in 360 years, so that about Christmas, 2231, we shall have to look for our supply of coal from the sub-Permian deposits at a depth below 4,000 ft. The Commissioners admit that every hypothesis must be purely speculative, but that if the present rate of increase in the consumption of coal be indefinitely continued, even in an approximate degree, the progress toward the exhaustion of our coal will be very rapid.

The caisson for the New York pier of the East River Bridge has been towed safely to its position.

THE HEMATITE ORE AND IRON OF CUMBERLAND.

From "Engineering."

The famous hematite ores and pig irons produced in that narrow strip of North Lancashire which runs into Cumberland are generally colloquially included with those of West Cumberland itself. We have followed this fashion in the above title, though the important works we describe elsewhere, as several others of those hematite districts proper, are situated in Lancashire. Then we could not well talk of *the* hematite district, as hematite iron ore is found in other parts of the United Kingdom. This custom of speaking of hematite iron, as if it came from West Cumberland only, is no doubt due to the fact that it was first produced near Whitehaven, in that county. So late as 1856 only one ironworks, that of the Whitehaven Hematite Iron Company, was producing hematite pig. It is to this establishment, therefore, that is due the credit of proving the productibility of a first-class pig iron from hematite ores alone by the use of coke; and their iron, termed "Cleator Moor," from the name of the place, near Whitehaven, where it is made, is of course very well known indeed. They then possessed three blast furnaces solely using the ore of the district. Since the demonstration of the Bessemer process, other competing works have rapidly risen up at the bidding of its magic wand; and the following may be looked upon as a complete list. The works at present in existence are beginning with the first established:—The Whitehaven Hematite Iron Company, making at Cleator, near Whitehaven, with 6 furnaces, the pig iron of that name; then for size, the Barrow Iron and Steel Company (Limited), at Barrow-in-Furness, 14 furnaces, with the Duke of Devonshire as chairman; the Furness Iron and Steel Company (Limited), with 2 furnaces in blast and another nearly finished, whose works we are describing; the West Cumberland Hematite Iron Company (Limited), 5 furnaces at Workington; the Millom Hematite Iron Company, 5 furnaces, at Millom — a small place on the other and northern side of the river Duddon, nearly opposite the Furness Works; the Maryport Hematite Iron Company of Maryport, 7 furnaces; the Solway Hematite Comany (Limited), 3 furnaces, also at Maryport, and adjoining those of that name; the Workington Iron Company (Limited), 6 furnaces, of Workington, who also convert their own pig iron; Messrs. Bain, Blair & Patterson, of Harrington, 4 furnaces; and the Carnforth Ironworks, 5 furnaces, not very far from Askam itself. To be soon at work are two new companies — the Lonsdale Hematite Iron Company, situated near Whitehaven; and the Moss Bay Hematite Iron Company, near Workington.

Now the whole of this so important iron district, with its portentously sudden growth; with its port of Barrow-in-Furness increased some twenty-five fold within the last ten years; with the fabulous fortunes—in some instances incomes of from £40,000 to £50,000 per annum —that have already resulted to the fortunate original lords of the mines; with its numerous works and innumerable pits that threaten to turn the loveliest district in England into another Black Country; with a production risen from 225,000 tons in 1854 to 1,047,819 tons in 1869; with this production augmented in 1870, and daily rising; represent neither more nor less than the simple chemical fact that good iron, and still less good steel, cannot be produced from pig containing phosphorus—more especially if that steel be produced by the Bessemer process. Day by day experience has shown that, for some reason or other—for science has not yet discovered any reason, though she has helped to remedies—a little excess of phosphorus in the composition of iron destroys its structural value. From two to three thousandths per cent. of phosphorus have little influence on iron; seven thousandths per cent. make it brittle or cold short; so that the prosperity of this hematite district may be said to be mainly a result of this difference.

A minor, but still important, qualification is the situation of the ore along a line of coast studded with fine harbors. Running the eye up the coast line, stopping at the magnificent Solway Firth, closely skirted by the railway, one sees in succession Barrow-in-Furness, Raven-

glass, Whitehaven, Workington, Maryport. The situation of these hematite beds, with the works growing out of them, is, in fact, exceptionally splendid. Already, before the late rapidly increasing demand for hematite pig to be used in the Bessemer steel-works of England, and for mixture with the spathic ore pig of the Westphalian steel works, or the French pig irons smelted from the ores of Corsica, Elba, and Algeria, most of the ore produced was shipped to the iron-works of Staffordshire, South Wales, and of Scotland, where considerable quantities were also used for "fettling" the puddling furnaces.

Much pig iron for the time, was already made at Ulverstone during the latter part of the last century—of course with charcoal—the Back Barrow bar iron being held in as good esteem as Swedish by the Sheffield steel converters. Going back to yet earlier times, we find authentic records that these ores were worked in the middle ages; and there is also very strong evidence that the Romans, who seem to had a marvellously keen faculty for exploration, had iron mines in West Cumberland. There can thus be no doubt that the ores of Cumberland have been worked from immemorial times; and that the iron they produced has served for many an old knight's elaborate suit of that armor, a glance at the relics of which shows what good smiths and fitters they must have had in those days.

As in Westphalia, these hematite beds are mostly found in the carboniferous limestone. To the careless eye they would appear of almost boundless extent, but the true reason of this is their irregular diffusion, not in veins, but in so-called "pots" or pockets, also in hollows, and but seldom in the form of true veins. The first question is, how these hollows were made in the limestone. This appears to have, in many instances, occurred by means of the erosive action of water; as the sides of the hollows are generally marked or striated as if by its flow. Smooth faces, exhibiting such striæ, often intersect the mass of iron ore near its boundary, also proving the fact of settlement or disturbances. The hollow being once formed, then comes the more difficult inquiry as to how, or at least when, they were filled. Strong reasons have been given for supposing that these ore deposits originated during the carboniferous epoch, and have been deposited in the erosions of the mountain limestone in most cases, or, as in others, interstratified in regular beds like coal seams. Fossils of well-known plants of the coal measures have also been discovered metallized into hematite iron in a similar way as coal plants are found turned into the carbonate of the protoxide or the bisulphide of iron or carbonate of lime. The ligneous structure of the plant has often formed the mould, so to say, for injections of peroxide of iron. These observations bear more especially upon the deposits of ore of the Furness district of North Lancashire. Near Whitehaven, in Cumberland, there are true veins of hematite occurring in the older slates, porphyries and syenites, as at Black Comb, Dent Fell, and Ravenglass. In the Cleator district, near Whitehaven, a narrow band of limestone on the clay slate curves round the flank of Dent Fell; and most of the mines of the Whitehaven district are found here. It is near the Red Pike mountain that iron is believed to have been smelted in the time of the Romans. But, on the whole, it may be held that the exact geological position of hematite ore is not very definite. There are two principal sorts of hematite worked in the district, locally designated as "hard" and "soft." More particularized, we find four kinds:—(1) A very dense massive form, with a conchoidal fracture and a dense blue color; (2) mammellated concretions, termed in the district "kidney" ore, showing when broken a fibrous, silky lustre, and a blueish, steel gray color; (3) a very soft variety, which may be rubbed between the fingers; (4) specular iron in small crystals of a six-sided rhombohedral form.

Hematite ore is found in several other districts in Britain, but seldom, if ever, so free from phosphorus and sulphur as in the hematite districts *par excellence* of North Lancashire and Cumberland. Near Cardiff, for instance, the hematite found there contains more than one per cent. of phosphoric acid, and still more sulphur. The hematite of Lantrissant, Glamorganshire, contains rather less impurity—from about one-tenth per cent. phosphoric acid, and nearly four times as much sulphur. The chemical character of the West Cumberland ore is generally that of nearly pure anhydrous sesquioxide of iron. It is, how-

ever, mostly mixed with very minute traces of lead, cobalt, tin, arsenic, and even of sulphur; and also of manganese, alumina, lime, and magnesia. The distinguishing features of most of these ores is the presence of a considerable proportion of silica, and the absence of manganese. The almost entire absence of manganese in the hematites of Cumberland and North Lancashire cannot be accepted as evidence that this adjunct is not indispensable for the Bessemer process. The converter charges at Sheffield, in Westphalia, and Styria, are not merely dosed with *spiegeleisen* at the end of the operation, but are also mixed with a proportion of Forest of Dean or Swedish or Westphalian pig iron respectively. But these characteristics may not improbably account for the somewhat red-short quality of malleable iron *puddled* from Cumberland pig. In this process, manganese, which apparently has the power of removing silicium from iron, is not generally used. But the high temperature required, according to strong evidence, by the manganese for exercising this power, is certainly present in the Bessemer converter, and just at the end of the process, when the spiegeleisen is poured in. Generally the iron made from the West Cumberland hematites has the reputation of being very red-short when other kinds of pigs are not employed; still we know that 5-ton "blows" of first-class steel are made from a composition of which nearly 100 cwt., or five tons, consists of three different kinds of Cumberland hematite, with admixtures of only 10 cwt. of Swedish pig and 15 cwt. of Forest of Dean.

An analysis made at Konigshütte in Prussia, of Barrow hematite, afforded 4.50 per cent. of silicium, 3.3 graphite, 0.08 combined carbon, 0.04 phosphorus, 0.09 sulphur, and 0.57 manganese. This gives a somewhat lower character, as regards purity, at any rate to Barrow pig iron ; while the proportion of manganese is unusually high. From a different source we have an analysis of gray pig No. 2, smelted with coke at Hochdahl, in Siegen, which gives 1.81 per cent. silicium, 3.39 graphite, 1.07 combined carbon, 1.08 manganese, 0.043 sulphur ; 0.006 phosphorus—the difference being iron. There is no doubt that a little phosphorus is always present even in Bessemer steel converted from the best brands. We know that, in the course of hundreds of blowings carefully investigated by spectrum analysis, the sulphur and phosphorus lines were never absent. But—and this is just the weakness of spectrum analysis — these determinations were simply qualitative, not quantitative. We all know how good is Krupp's steel, and according to analysis by Mr. Abel, of Woolwich, it contains as much as 0.02 of phosphorus, 1.18 combined carbon, 0.33 silicon, no sulphur, a trace of manganese, 0.12 cobalt and nickel, and 0.30 copper.

We are not of the opinion, held by some, that it is probable that the iron industry of Cumberland will ever expand to the extent of that of the Cleveland district. The indispensable element of cheap production is wanting. In the first place, the pure blast furnace coke required has to be fetched from the Durham ovens, which involves a not inconsiderable freight for an article in large demand already. The coke used has to be as much as possible chemically free from sulphur, and to be in large pieces for the passage of the blast—already somewhat difficult on account of the small size of the ore. It is possible that progress in washing and coking the inferior coal found nearer than Durham may make some change, but this has not yet taken place. Then the ore is not found so regularly and in such quantities as might be desired. The best proof of this is to be found in the fact that the royalties on the ore have risen from 1s. 6d. to 3s., and even to as much as 5s. 4d. per ton. In the Cleveland district they are never more than from 4d. to 8d. The price of the hematite ore itself has risen 7s. per ton above what it was 12 months ago. This may possibly be somewhat due to the undoubted revival of trade now taking place ; but, in any case, as the Cumberland ore lies far away from sulphur free fuel, pig for steel making will never be made at much less than 70s. per ton. The prices are now much higher.

THE "Scientific American" says that the total area of the known or explored coal-fields in the civilized world, independent of the American coal-fields, are less than 20,000 sq. miles. When compared with the immense areas and extent of the latter, how small and insignificant the former appears.

CRITICAL EXAMINATION OF THE IDEAS OF INERTIA AND GRAVITATION.

By JAMES D. WHELPLEY.

1. NATURAL LAW OF GRAVITATION.

Astronomy, as a true science, was founded upon Kepler's discoveries of the elliptical form of planetary orbits, and the law of equable areas. This law is based upon the facts discovered by Kepler, that the orbitual velocity of planetary bodies increases or diminishes in a simple ratio as they approach or recede from the solar centre. Newton, in view of Kepler's observations, introduced the idea of a *nexus* of force, binding together all the numbers of the solar system by a mutual gravitation.

It was thought proper by its discoverer to assume that the intensity of this force should vary inversely as the square of the distance between the gravitating masses. By this it would be found always in a correct mathematical relation with planetary distances and velocities, and would always counterpoise the tangential force.

Although the Newtonian formula for the radial tendencies of the planets, in counterpoise with the tangential, is found to be correct in the method of its use, as a formula of calculation, it is nevertheless demonstrable that this formula does not represent the intensity of gravitation, but is in fact a mathematical expression for the rate of variation of the falling force, or radial motivity, of planetary masses, in reference to the solar centre. In other words, it expresses the initial motor force of planets drawn in their orbit towards the sun.

Assuming that the radial and tangential forces are effects of independent causes, then the radial force in a *circular* orbit is a constant; a steady pressure, always equal to it itself, holding the planet against the action of the tangent force at an invariable distance from the sun. It is then a pressure acting with a constant velocity through equal spaces in equal times, and is represented by the formula, *pressure* × *velocity* × *distance moved through*, or p. × 1 × 1, for the first unit of distance of the planet from the sun. At one-half of that distance, velocity, by Kepler's law, being inversely as distance, the second term of the formula (velocity) = 2. If we now assume that the force of gravity varies, like the velocity, *inversely as the distance*, we shall have 2 p. × 2 × 1 = 4 = radial motor or inertial force at one-half of the same distance from the sun.

Let the velocities, at successive distances, be represented by the series 1, 2, 3, 4, 5, etc., inversely as distance. Let the cause of these velocities, that is to say, the actuating force of gravity, be represented in its degrees by a similar series, also inversely as the distance, in a simple ratio; then, the time being always unity, a multiplication of each member of one series by the corresponding one of the other gives 1^2, 2^2, 3^2, 4^2, 5^2, etc., as a third inverse series expressing the diminution of radial motor force, or tendency toward the sun, at increasing distances. Although these numbers are the same with the Newtonian formula of the distance square inverse, they do not express the intensity of the gravitating force, but only a result of intensity evolving a motor force through the intervention of velocity.

Since it is thus demonstrable, by exact reasoning and deduction, that the pressure of gravitation does *not* vary as the distance *square* inverse, but simply as distance inverse, it has been necessary to reconsider the theory of this force and of mechanical power in general as dependent upon it, the place of the hypothesis of Newton being vacated.

Because all bodies falling freely near the earth are associated with it in movement by the law of gravitation, and move in elliptical orbits determined by terrestrial *foci*, the motor force of such bodies will be represented by the same formula that expresses the law of the radial tendency of the planets.

Thus, in the instance of a cannot shot, setting aside the resistance of the air, the trajectory would be elliptical, and in no respect different in nature from that of a comet. The impulse of the explosion communicated to the ball would evolve the tangent force, and gravity the radial.

Any mass of matter in orbitual motion has attained its velocity by degrees, from a point of rest, under the action of an accelerating force, either constant or variable; but in either case the tangent

movement of a projectile or of a planet is subject to the same laws of acceleration or diminution that govern a fallen body. Its momentum will vary as vel.^{2}, and we have seen already that this formula is a component of two equal elements, the actuating force or pressure (p.) and the space passed through in a given time (v.) *If the actuating force varies, the velocity varies in the same degree.* Hence the motor value, when mass and time are constant, varies as vel.^{2} in all cases of momentum. But this mathematical expression (vel.^{2}), has no value in a philosophical sense, and does not express the nature of motor force.

The motor force of a mass accelerated under a constant following pressure like the force of gravity, will increase in the degree that it passes through or occupies space. When it has attained a relative velocity of 10, *e. g.*, it will have fallen through 100 cubical units of space, and will have acquired 100 units of motivity.

The space occupied during the increase of its motion from rest, by a mass free to move and subject to an accelerating pressure, is the measure of the motivily which it has acquired.

Space is occupied by force in at least two modes, by volume, and by position and linear motion. The expansion and contraction of gases under the influence of heat and cold illustrates the development of forces, and their measure, in the occupation of space by volume. Movement through space, represented by the successive cubic units occupied in a given time, illustrates the second mode. *The force of inertia, on the other hand, is the occupation of a position in relation to other bodies.*

It is not possible to ascribe a dynamical value to the abstract idea of empty space, or of motion through it ; but when it is remembered that the position of a body in space, and its volume, belong to it by virtue of a forcible relation with other matter, it will be seen that any change of these can be brought about only through change of such relations. In other words, the space passed through, under the described conditions, measures the quantity of motion transferred to the vibrating substance of the moving mass. But it is necessary to discuss other points before entering fully upon this.

A body moving freely unde the gravitating force must have attained its velocity by increment or decrement, under the natural law of the evolution of motor force. A planet approaching the sun has its motor force augmented by a gravity of which the intensity increases as the distance diminishes, and an increase of velocity consequent thereon in equal ratio. One component is the simple increase of the actuating force ; the other measures itself by the larger space traversed because of that increase, marking the rapidity with which the pressure or actuating force is absorbed or communicated.

2. NATURAL LAW OF INERTIA.

If two masses are in gravitant relation they move relatively to one another ; but if the matter of one of them happens to be distributed about the other in a shell, at any distance, there can be no reciprocal movement, and this is a necessary deduction from the observed facts of gravitation. But we cannot suppose that the dynamic relation which we find everywhere existing between the particles of matter is cancelled by any particular form of distribution ; it has, on the contrary, the same value, but with a different effect. Matter at the centre of the earth can have no "weight," being equally influenced on all sides by the mass of the earth ; but we are not therefore to infer that *because there is no direction in which it can fall,* this central matter does not evolve dynamical effects equal to the full results of the superior influence of the earth as we approach its centre.

The weight of a terrestrial body being only its initial tendency toward the centre, there are many ways in which it may be masked and yet not diminished. Bodies floated or supported by air or water, or by centrifugal force, or by counterpoise on the two arms of a balance, etc., are examples of a masking or disappearance of "weight" or initial motivity toward the earth's centre, and of the appearance in its stead of *inertial* force, such bodies resisting all attempts to move them *in any direction*, whether toward or from the centre, with a force called "inertia," and which is measured by gravity ; for in estimating inertia we begin with the element of "weight" as with its original.

Weight being a motor force is compounded, like other forms of evolved force, of a fixed number of elements. The

weight of the earth pressing toward the sun in its orbit, or a weight turning the scale of a balance, are compounded alike of the quantity of matter, the intensity of gravitation, the velocity of motion, and the duration of the movement, and of the first and last are taken as units; weight varies as the intensity of gravity multiplied into the velocity of movement in the direction of the force.

The effects of the gravitating masses upon each other are found to be such, that any two masses in space at an appreciable distance, free of all obstruction, will move always in parallel and opposite directions, with velocities inversely as their masses, and with equal forces. The earth and the sun are relatively "floated" on the orbit, and their mutual "weight" is masked, taking the form of *inertia* and of momentum.

It is a fact of common experience that a particle of matter, whatever may be its condition or dimension, retains for itself a certain bulk or volume of space, which is proper to it, and is variable only within measurable limits; and also a certain position in space *in regard to other bodies.* But neither of these properties can appear or be evolved, except by virtue of relations with other matter. The volume of a mass or particle is made evident by pressure; it limits the approach of other bodies. The position of a mass is manifested as to its strength by the *time* it occupies in yielding to a definite and constant pressure, and this is called its *inertia.*

What is true of the mass must be true of the ultimate particle. A single atom of matter, the only one in existence, would evolve neither weight nor inertia, but give it a companion, it would have both. Let now a vast number of atoms co-operate in evolving the qualities of weight and inertia in a single particle; it will be seen that these qualities grow or diminish by relation.

The force with which the earth holds its position in space is due to its relations, first, with its own component atoms, an accumulation of atomic influences by the reciprocity of which terrestrial inertia and gravity is evolved and determined. Second, its relations with the sun, which communicates to it an inertial force $\frac{1}{1600}$ as great as its proper gravity. Finally, the influence of the moon, and of the planets, and of the cosmical system of dark and bright bodies, must be counted among the causes of the earth's inertia.

Common experience measures the degree in which masses of matter resist pressure by their weights. Gravity, whether it be equipoised or not, producing either relative motion or relative rest, is the measure of inertia, and the force with which the earth resists the perturbing influence of another planet is generated not only by its relation with its own component parts, but with every particle of matter in the universe.

This is the natural idea of inertia drawn from common experience, and in the most recent works of the great scientists inertia is made the converse of momentum, momentum being measured by the time required, with a given pressure, to bring a moving body to rest, and inertia with an equal pressure to restore its original velocity.

The ideas of inertia and momentum adopted by Newton, and made the basis of his system, are entirely different from those of modern writers.

Newton's best expounder, Maclaurin, defines inertia to be a constant property of bodies by which they remain at rest for ever, unless compelled by an external force, and continue always in motion in a right line with their last acquired velocity and direction, unless checked or accelerated by an external force. Inertia in the Newtonian system was a constant, and determined the "quantity of matter in a mass." Momentum was measured by multiplying velocity of motion into quantity of matter moved, that is to say, multiplying inertia by velocity.

These ideas are no longer available for use in mechanical philosophy, motion and rest of bodies being known by common experience to be always and presently determined by external relations.

Newton was obliged to assume that inertia, "the force which resists gravitation," is invariable, because he made the intensity of the gravitating influence to vary as the distance square inverse, an hypothesis which, as we have seen, does not express a natural truth.

3.—RELATION OF PLANETARY INERTIA TO GRAVITATION.

A falling body near the surface of the earth does not begin to fall at the mathe-

matical instant its support is removed. The movement is not only not mathematically instantaneous, time being required for propagating motion in matter, but the increments of motion in falling are equal, definite, and require a precise expenditure of time. The rate of acceleration varies with the intensity of gravitation, being less at the equator and more at the poles, less on the summit of a mountain, and again less as we descend beneath the surface of the earth. The velocity of acceleration, being determined by the intensity of gravitation, diminishes in the direct and simple ratio of the distance from the centre of the earth, above the surface, the earth's semi-diameter being taken as the unit of distance.

The most noticeable and material fact in the phenomena of falling bodies is their resistance to any acceleration by downward pressure. The fall of a body toward the earth can only be hastened by a downward pressure *added* to that of gravity. The falling is at a fixed rate of speed and acceleration, which must not vary except under known laws of distance and mass. The resistance offered by a falling body to a force urging it downward in excess of its natural rate of falling, is the same inertia that resists the motive force of gravity, or any other external motive force. *But this inertial force for a given mass is also determined by the intensity of gravitation, and this again by distance.* Let two plummets hang side by side. They are drawn toward each other by a measurable force of gravity, as much less than the force which draws them toward the earth as their *mass* is less than that of the earth. The earth may draw them with the force of a pound weight each. They draw each other with a force many billions smaller ; the inertia of a mass at the surface of the earth is determined by its mutual gravitative relations with the earth. But the inertia determines the density, and density, other things being the same, is the measure of gravity. The degree with which the two plummets attract each other will consequently vary with the earth's influence ; it will be less,for example, at the summit of a mountain than at the level of the sea.

The motion of falling bodies must be produced by some simple and invariable cause common to all kinds of matter under all conditions. The first effect of the earth's mass upon a body is to give it a certain degree of immobility, which is the base of inertia. The second and subordinate effect is a movement with a definite and constant acceleration, the inertia being not affected by this movement, but always the same at equal distances from the earth's centre.

We know of no masses moving in space that move by their inertia ; they are all, as far as observation takes us, controlled and urged by the effect of gravitation.

4.—NATURAL CAUSE OF THE MOTION OF FALLING BODIES.

Since inertia never of itself produces motion, and is nevertheless the first effect of masses upon each other, some other conditions must be found in which inertia is an element, to account for the motion of falling bodies.

Let us imagine two homogeneous spheres of some definite size, substance, and density, differing from each other only in that they occupy different positions in space. The two spheres are mutually impenetrable and individualized, but exactly in the same manner and degree ; they discover no differences except those of position ; but this also implies that the units of matter that compose them are severally at unequal distances, and this simply because each has a place and volume of its own.

Every day experience bears testimony to a fact which is also supported by the most refined analysis, that rest or quiescence is a result of the balance of forces, and motion, of their inequalities. This condition being universal, it must be true that the motion of falling bodies must be a result of unequal pressures. Between the two spheres that we have been considering, there is but one possible inequality, and that is determined by the nature of space itself, and of matter as its occupant. The two spheres, being free to move in space, will, as experience testifies, move in relation to each other. But because all motion arises upon an inequality of forces, and since none other can be discovered, save the unequal distances of the parts of the two spheres, the natural cause of falling or gravitating must be looked for within this difference, and not elsewhere.

A mass equally influenced on all sides by gravity, as at the earth's centre, or in

a hollow sphere, would not have motion. Inertia is equal in all directions, varying only with distance and quantity. Between every pair of separated molecules, because each of them has position and volume, there is the inequality. The first effect of the two particles must be to assign each other position in space; and because their power of doing this diminishes with distance, it follows, that between any two masses, the parts of each that are nearer will affect each other more powerfully than those that are more removed; and this inequality determines a movement in the direction of the greater force.

5.—RELATION OF MASS AND DISTANCE.

The "weight" of the earth increases as it approaches the sun. The elements of the weight are the intensity of gravitation and velocity of fall; which, when multiplied into each other, give the expression for radial motivity. The first element, intensity of gravitation, is the same with an increase of inertial value or immobility of each particle composing it, and an immediate consequence of *this* increase is the augmentation, in the same ratio, of "gravity," the first element of motivity. If the quantity of matter in the sun were doubled, the effect would be the same upon the earth as though it were at only half distance from the sun. Each of its particles would have a double inertia and a double gravitating force. The velocity of fall would increase in the same ratio, and the radial motivity would be quadrupled.

Increasing the quantity of matter in the solar centre would augment the radial motor or falling force in the duplicate ratio of that increase.

If the earth had been drawn toward the sun with one unit of velocity and one of gravitating influence, were the mass of the sun doubled, it would fall in the orbit with two units of each of those elements, and the multiplication of these would give four times the motivity, etc. The inertial element, or force of position, is doubled, and the solar tendency must be doubled in consequence. Increase of the solar mass has, then, the effect upon a planet of a nearer approach to the sun, and when the effects are the same the causes must be. Increase of the number of material units composing the mass is the same, in effect, with diminution of the number of units of distance. The effect of both is to increase the dynamical force of the planet in a simple ratio, force of position (the basis of inertia) first, and gravity in the same degree.

6.—MOTOR FORCE EVOLVED BY INDUCTION.

In the case of A and B—two unequal masses gravitating mutually in space—it is first evident that, as in terrestrial gravity, each has an action upon itself, creating a "proper" inertia. Let the force of position evolved in A be to that of B as 1 to 10. Then A being the unit of a mutual force, which is independent of the individual or self-determined gravitations of A and of B, each unit of B is in gravitating relation with A, *by which A acquires 10 units of communicated force.* A, on the other hand, communicates one unit of the same force to each member of B. Then, A, having 10 units of force, will have 10 of initial velocity or weight in relation to B; and, because the multiplication of the two gives the momentum, A will have 100 motor units. But B has for each unit only *one* of velocity; the momentum of its mass is then apparently $1 \times 10 = 10$. Which is untrue.

For we learn by observation, that the velocity of B being 1, its motor force will be 100, equal to that of A. It follows from this, that the force *evolved* in B is not 10 but $100 : 1 \times 100 = 100 =$ motor force of B and of A. There is no possible mode of explaining this difference, but by assuming that the evolution of force in B is as the square of the number of its units, or as $10 \times 10 = 10^2$. But by the same rule the evolution of force in A should also be *as the square of the number of the units of force evolved in it*. Which is true.

If velocity—a mathematical expression for relative rate of motion through space —were a force itself, and not merely an index of the rate of evolution of forms, it would be philosophically correct to say that the motor force of A is as the number of units of force evolved in it by the action of each unit of B ($= 10$) multiplied by the velocity consequent on such evolution: $10 \times 10 = 100 =$ motivity of A $=$ motivity of B. But if we regard velocity as what it is, namely, *the index of the rate of evolution,* then the velocity of A really indicates the evolution in itself of 10 additional units of force for each one of the original units of gravitation. But $10 \times 10 = 100 =$ motor force of A $=$ motor force

of B. Hence the *motor force of any two masses in mutual gravitation will be as the square of the number of units of evolved force in either.* It has become evident that velocity must be regarded only as a result, and not as a cause, of the evolution of forces. And the same is true of motion in general, which is always a result of dynamic inequalities.

If the above reasonings are correct, mechanical motor force is inductive, and no mass of matter can be influenced by gravity without communicating this effect inductively to all bodies within its influence.

GUNS VERSUS TARGETS.

From "The Engineer."

"The Woolwich Infant," otherwise Mr. Fraser's 35-ton gun, has just been bored out fron 11.6 in. to a diameter of 12 in. From some inscrutable reason, it refused to burn all the powder which it was desirable to burn. Better results are expected now, because the charge will occupy less length of chase. The trials will not be made, however, for some weeks. Meanwhile the Woolwich gun factories are not idle. Whether the 35-ton gun will or will not burn 120 lbs. of powder, it is certain that it is or can be made by certain modifications in the gun, the projectile, and the powder, the most powerful weapon in existence. Col. Campbell hopes to have ready by January, thirteen 35-ton guns, eighteen 25-ton guns, one hundred 18-ton guns, and a host of smaller fry. This is pretty well for a year's work. There is no other nation capable of doing so much, if we consider that, thanks to Mr. Fraser, all these guns will be sound and reliable weapons, fit for the worst vicissitudes of warfare. Recent experiments at Shoeburyness have led us to conclude that of late the guns are having much the best of the battle which has so long been waged between them and armor plates. It is doubtful if better plates can be made than are made now. They may be punched by shot and shell, pounded by all kinds of guns and all kinds of projectiles, but they no longer crack and split to pieces. They behave like copper. It is, indeed, just possible that we have got a little too far, and that our armor plates are too ductile, and offer a less resistance to the passage of shot and shell than would a harder material. It is beyond question that circumstances might arise in actual warfare under which a plate which cracked with the impact of every heavy projectile, until it hung in scales over the structure it was intended to defend, yet kept shot and shell out, would be better than a plate which could not be broken, yet allowed projectiles to get through. In a combat, short, sharp, and decisive, the former would be the best, although under prolonged pounding—such as might take place when a fort was besieged—the latter would have the advantage. An embrasure, defended by hard plates, might be stripped in a couple of hours; but if the attack did not last more than an hour, for that hour the men behind the shield would be much safer than they could possibly be behind armor plates which could be punched by heavy shot or shell, but which could not be broken off until they had been reduced to the semblance of lace-work by a multiplicity of perforations. We know that it is generally held that a plate cannot be too ductile. The question is worth considering, however, from our point of view. If a single heavy shell finds its way into either turret, or embrasure, or ship, the chances are that the fight will be at an end as far as that turret, embrasure, or ship may be concerned. Sooner or later the gun must beat the plate, if the action be only sufficiently prolonged; but it would be a matter of little consequence how many shots a plate could stand before it fell off if it was once fairly penetrated. Every minute which could be spent in action before a projectile got through might be worth thousands of pounds, and if it were only possible to defy an enemy's guns for an hour, and if the action could be concluded in that time, it would matter little whether the shield, or the turret, or the ship's side were practically ruined at the end of sixty-one minutes. We do not wish it to be understood that we advocate the use of brittle plates. All that we maintain is, that for actual warfare that target is the best which totally prevents the entrance

of projectiles for the longest time. Half-and-half targets which cannot be broken up, but permit an occasional projectile to get in now and then from the first, will prove useless except in the case of long sieges. The first shell that gets in will destroy the gunners and dismount the gun. On shore a new crew and a new gun may be had, but this argument will not hold good at sea.

Under existing arrangements the guns have many advantages over the plates; a certain point of perfection in the manufacture of these once reached, nothing remains but to increase the thickness of the plate or to strengthen the backing. The guns, on the other hand, can not only, if time be allowed them, go on pounding the plate until it is reduced to fragments, but they can use all manner of cunningly compounded chemicals, which, put into a shell, inflict fearful injuries on the plates. We believe that the limit of perfection has been nearly reached in the plate. We are not yet even near it as regards the gun. The more experiments we try at Shoeburyness, the more conclusively is this fact proved. Our ships cannot well carry any more armor than is now packed upon them. Indeed there is reason to think that they have too much already. The question naturally arises, is there no way to dodge the shells, which by brute force, as represented by heavy plates and thick backing, we cannot keep out? It does not seem, however, that this question has ever been discussed as it deserved, and different inventors have proposed the use of elastic media, such as compressed wool, cork, india-rubber, etc., as a solution of the problem; but all these things have completely failed on trial, and probably that is the reason why so little has been attempted in the way of eluding the action of shot and shell. Let us see whether the belief that projectiles can only be kept out by heavy plates and backing, and, further, that if these will not keep them out nothing else will, is well founded.

Now, in the first place, it may be taken for granted that we do not possess a single iron-clad which cannot be penetrated at short range by the improved 35-ton, or even by the 25-ton gun. It may also be taken for granted that we cannot put on any thicker armor than we use now, unless we leave large portions of the ship unprotected, or make her of colossal proportions. Consequently we must try something else, except we are content to leave the victory with the guns. What shall the something else be? In order to answer, we must consider what actually takes place when a shot or a shell strikes a ship. If the first is of a brittle metal it breaks up in going through. The head goes on as a solid shot, followed by a shower of splinters more formidable than grape. If the shell goes through, it bursts practically just inside the plate, spreading ruin and death all round ; 1 shell between decks is worse than 20 solid shot. If there were no shells, big guns would be of little use. It would be better to build ships very thin and let the shot go through them unbroken, than to provide plates just heavy enough to convert the comparatively harmless shot into mischievous grape. All our energies should be concentrated on neutralizing the effect of shells. If we can but manage this, there is little to dread from shot. Now, shells used against armor plates in the present day are fired by the concussion of the shell against the plate without fuses of any kind. A plate 3 in. thick will suffice to explode a shell. The moment explosion takes place the shell is converted into fragments, which scatter on every side according to the lines of least resistance and the direction of the initial force. For the purposes of penetration as regards the iron plates, the shell, after the explosion, is as harmless as a handful of sand. The explosion may take place at precisely the same instant that the shell is going through a plate. The latter will then hold the shell together, and the whole effect will take place inside. Bearing this in mind, let us suppose that a $4\frac{1}{2}$-in. target, properly supported, is put up 200 yards in front of the 25-ton gun, and that 20 yards behind the first a second target, also of $4\frac{1}{2}$-in. plate, is put up. Does any artillerist believe that it is possible to get a shell through both these plates? We venture to say, not one. The shell will explode just inside the first plate and be converted into fragments, not one of which will be able to get through the second plate. A solid shot made of steel or other very tough material will get through, no doubt, but not shell. Shells fitted with time fuses have been fired at plates, and exploded prematurely. They never did any

harm. It is, above and beyond all things, essential that the projectile which is intended to get through a plate must not break up ; if it does, farewell to penetration.

Here, then, we have the true solution of the problem : how shall we keep the shells out with armor of moderate weight? Break up the shell before it touches the armor plate. This done we have nothing to fear.

A very careful search through the official records of armor-plate experiments has failed to supply us with a single instance in which the principle we advocate has been tried. The obvious method of applying it in practice consists in using 2 armor plates, the outer one thick enough to explode the shell, and the inner one thick enough to keep out the pieces, with an intervening space, quite empty of everything but air, and of considerable width. An experiment was tried some time since, of which we can find no record, in which one plate was put thus behind the other. Solid shot, not shell, was used, and even in this case the results obtained were considered promising; but an experiment was tried still more recently at Shoeburyness, in which the target consisted of 2 heavy plates with baulks of timber intervening. In this case the shell got through, but in neither one case nor the other were the conditions precisely such as we contemplate. We admit that solid shot will not be kept out if it is tough and strong, and, therefore, we may dismiss the first experiment. In the second, the 2 plates were built up in a continuous target, one backing the other, while the timber confined the effects of the explosion of the shell, holding the latter together, so to speak, until it got through the second plate. We propose that there should be no filling in whatever between 2 plates. What is the least distance that should intervene between them, we are unable to say. We wish the authorities would conduct one or two experiments to find out. If it need not exceed 4 ft., or thereabouts, there will be no difficulty in carrying the scheme into practice.

THE INFLUENCE OF CERTAIN METALS ON THE QUALITY OF STEEL.

From "The Bureau."

We know that steel is a combination of iron and carbon, and that its hardness may be considered to be in a ratio with the proportion of carbon it contains. Nevertheless, it has been often remarked that two different kinds of steel, with the same proportion of carbon, will behave differently when worked into tools or when hardened or welded. These differences may result from different causes, such as the methods by which the ore and the metal have been worked, impurities in the ores, or certain metals in the ores the presence of which had been overlooked.

The metals which appear to impart valuable properties to steel are : aluminium, silicon, vanadium, manganese, chromium, tungsten, and titanium.

Aluminium and silicon, to the presence of which are attributed the qualities of the Wootz or Indian steel, have been found only in traces in the analyzed steels. They appear to increase the hardness and the fineness of the grains of the metal.

Vanadium is found in certain magnetic ores of Sweden, Maryland, and North Carolina, and in the metal extracted therefrom. Very little is known about its properties, except that the iron which contains it is generally of excellent quality.

Manganese has evidently a beneficial action—so much so that it is doubtful whether the Bessemer process would have been a success without the employment of spiegeleisen. The peroxide of manganese is generally employed by makers of crucible steel, and iron ores holding manganese are in high repute. However, steel, when analyzed, contains only traces of manganese, and the excess of this metal which has been employed would appear to form a very fluid cinder which aids in the thorough cleansing of the melted steel.

Chromium forms, according to Berthier, perfect alloys with iron and steel, and increases their hardness. It has even been said that steel may be made directly from wrought iron and chromium without carbon ; but analysis has always shown that

chromium steels contain a certain percentage of carbon.

Tungsten steel, a few years ago, was presented to the public with so much puffing that, not answering all that was claimed for it, its qualities were at once entirely denied. This was unwise. The writer had once to drill holes in a piece of cast iron which had been accidentally chilled. A dozen of drills made from different brands of the best cast steel to be found were used unsuccessfully, when a friend suggested and furnished a piece of tungsten steel. A drill made from it by the same blacksmith who forged and tempered the previous ones, went through the chilled cast iron. The last drill contained only a trace of tungsten.

Titanium is also beneficial to steel, although chemical tests fail to show more than traces of it in the analyzed steel. It imparts hardness and toughness to the metal with which it is alloyed, and a steel made from titanium ores appears to bear more heat and be harder than an ordinary steel with the same proportion of carbon.

Except chromium steel, which may contain notable proportions of chromium, the other steels have been found by analysis to contain only traces of the above-mentioned metals, which, however, are sufficient to impart valuable properties of hardness and toughness.

Cast iron, on the other hand, may contain ponderable quantities of the above metals ; but in our present state of knowledge we are unable to say whether these rare metals are combined with cast iron and steel, or simply intermixed or alloyed. That their presence is beneficial seems certain ; but how much so ? and within what limits ? These questions, to be answered with certainty, will require time with the work and the evidence of several experimenters, and the aid of iron-masters.

The economical method of preparing these steels is by a mixture of their ores in suitable proportions, and their subsequent smelting and treatment by the new or old processes for making steel.

TITANIUM IRON ORES.

These ores begin to attract a great deal of attention, not only on account of their abundance in certain parts of this country, but also because the metal extracted from them is very pure and tough. They seem also peculiarly adapted to the manufacture of steel, and their almost entire freedom from sulphur and phosphorus, and their refractory qualities, make them a most valuable fettling material for the puddling furnace. Indeed, the owner of a rolling-mill at Philadelphia states that they last three times as long as the magnetic ores of Lake Champlain used for the same purpose.

The steel, whether high crucible steel or low steel by the Martin-Siemens process, is of first quality, and generally harder than ordinary steel having the same amount of carbon.

These titaniferous iron ores are magnetic, sometimes with an admixture of red oxide of iron, and are accompanied by small proportions of manganese, chromium, vanadium, magnesia, lime, alumina, and silica. They are in the form of sand, as the black sand of the shores of Long Island and of the Moisie river, Canada, or in heavy compact masses which require blasting. Those of intermediary degrees of compactness are the most abundant, and require only the pick-axe and the crowbar for their mining. The accompanying rocks are metamorphic, and composed principally of the following minerals : quartz, feldspar, mica, hornblende, talc, chlorite, serpentine, etc.

The principal deposits of titaniferous iron ores in the United States are in Northern New York, Missouri, Tennessee, North Carolina, Virginia, and Maryland.

The deposits in the northwestern part of North Carolina, owned or controlled by a Philadelphia company, have been found by a recent survey to extend in almost a continuous line for over 30 miles. The deposit, which affects the form of a nearly vertical vein, has a thickness of from 4 to 10 ft. The per cent. of titanic acid varies, but is about 10 on an average. The supply of ore may be considered as inexhaustible, and charcoal is abundant everywhere. Bituminous coal-fields will be soon reached by projected railroads.

These ores have, in this country, been worked mostly in bloomary fires, and but little in blast furnaces. But as the extensive use of such ores requires the employment of blast furnaces, it may not be amiss to say a few words on the proper mode of working them.

Titanium iron ores having the reputation of being refractory, it has been

thought that they needed only a high temperature for their reduction, and consequently they have been tried in admixture with other ores in high blast furnaces, with plenty of fuel, plenty of blast, and scarcely any change in the proportions or the nature of the fluxing materials. The result was, as it should have been expected, that scaffolding and irregular working occurred.

The failure was due to three causes :

1. A too sudden change in the nature and in the proportion of the charges. We know that a blast furnace is very sensitive to sudden changes in the nature and proportion of the charges of ores, fuel and fluxes, and in the amount and pressure of blast. A regular working requires a perfect adjustment of all these conditions. Therefore, if too large a proportion of a different ore is added at once, there is no time left to properly adjust the blast, the fuel and the fluxes, and a stoppage is imminent. The more different an ore is from those usually employed, the smaller should be the proportion added at the beginning of the experiment, and there should elapse from 8 to 10 days before the proportion is increased, thus giving time to ascertain and remedy the causes of the irregularties which may take place.

2. A too long exposure to the reducing gases. In high blast furnaces, the ores are for a long time exposed to the action of reducing gases. While this arrangement is suitable for the reduction of oxide of iron, it is not so desirable for titanic acid, which, when it loses its oxygen, combines with cyanogen and nitrogen, and forms a compound which, being irreducible and infusible, may cause scaffolding.

3. A fluxing not adapted to titanic acid. Neither the composition nor the quantity of slags produced in ordinary blast furnaces is suitable for titaniferous iron ores. Titanic acid is carried away in a fusible state by the magnetic slags of the bloomary fire. But this process is too expensive for blast furnaces, on account of the great loss of metal. Therefore, since titanic acid is soluble in metallic oxides, a cheap flux containing these oxides is to be preferred, and we find them among the minerals accompanying the titanium ores, for instance ochres, hornblendic and pyraxenic rocks, and other complex silicates with metallic bases. In this case the slags are suffered to contain a notable proportion of metal.

An abundance of slag, not too easily fluid, will carry away mechanically the titanic acid mixed with it.

If we follow the example of the Swedish iron-masters who have great experience in the treatment of similar ores, we will employ by blast furnaces of medium size, high enough to thoroughly reduce the oxide of iron of the ore, but not sufficiently high to reduce all the titanic acid ; and the fluxes will be chosen and adjusted to carry away the titanic acid, whether combined with metallic oxides or mechanically, as we have just explained.

We must add that, besides the fact that titanic acid can be fused with metallic oxides, there is very little known about the relative proportions in which these combinations take place, and that their study would be as instructive and useful to the iron-master as the similar combinations of the silicic acid with metallic and earthy bases.

TESTS FOR WHITE LEAD.

The *body*, or covering power of a paint is due to two causes—a great division of the substance, which allows it to be spread over a large surface ; and opacity which allows a thin coat to impart the desired color. It is evident that a transparent substance, however finely divided, will not sufficiently color the surface over which it is spread ; and, on the other hand, an opaque color, if coarsely divided, will not cover a large area.

White lead, if formed purely of carbonate of lead, will not have sufficient covering power. The opacity of the good white lead, manufactured by the Dutch method, is due to a certain proportion of hydrated oxide of lead, mixed with the carbonate ; and we may say that the more there is of hydrated oxide in the white lead, the more body it will have.

If several samples of pure white lead are submitted to chemical analysis, those containing the greater proportion of oxide of lead, with a minimum of carbonic acid, will be found to have the greater covering power.

Our object is to indicate a rapid process by which persons not conversant with chemical manipulations may ascertain the relative body of samples of white lead, not ground in oil. This test is based on

the phenomenon presented by yellow chromate of lead, when a part of its chromic acid is removed, or, in other words, when it is made to contain an excess of oxide of lead; the yellow turns to an orange shade, which is the deeper as there is more oxide of lead uncombined with the chromic acid.

Therefore, if we put same weights of different samples of dry white lead in several saucers, and pour upon them the same volume of a solution of chromate of potassa, a reaction will take place, by which the chromic acid of the chromate of potassa will unite with the lead of the carbonate of lead, forming a chromate of lead, which will be of a deeper orange shade, as there is more free oxide of lead in the sample examined.

The solution of chromate of lead should be added in excess, that is to say, should, after stirring it with the white lead in the saucer, and allowing it to stand for a few minutes, be still of a yellow color. The samples are examined after settling, and decantation of supernatant liquor.

As yellow chromate of potassa is generally alkaline, it is better to correct this alkalinity by employing a mixture of 18 parts of yellow neutral chromate of potassa and 2 parts of bichromate of potassa, dissolved in 10 parts of water to 1 of the dry salts.

If the dry white lead is adulterated with foreign substances, the orange color will appear, but will not be so deep in tone.

This test does not apply to paints already ground in oil, in which case it is preferable to mix the weighed sample with $\frac{1}{2}$ to 1 per cent. of lamp black, and a few more drops of oil if necessary. After thoroughly mixing lamp-black and white lead with a painter's knife upon a porcelain slab or a pane of glass, the samples are compared, and the lighter the drab shade is, the greater the coloring power of the paint examined.

EXPERIMENTS AT SHOEBURYNESS.

From "Engineering."

Notwithstanding the state of perfection to which our projectiles have been brought within the last few years, that perfection is at present only relative. Our manufacturers and others have therefore been endeavoring to render it absolute, and the War Office authorities have promoted, as far as they can, the discovery of the best metal for shot. In this interest mainly, our national experimental artillery ground at Shoeburyness was again the scene of some interesting trials, which were carried out this day week. The objects were to test the value of some new 9-in. chilled shot, supplied by Mr. Unger, of the Fingspong Works, Sweden; to try some 9-in. steel shell, supplied by Messrs. Firth, of Sheffield, and some 11-in. Palliser shell. To these was also added the trial of a new picric powder for shells, which is the invention of Prof. Abel of Woolwich. The experiments commenced with the Fingspong—or as they are playfully called at Shoeburyness, the "fishpond"—shot, fired from the 9-in. muzzle-loading gun, with charges of 43 lbs. of R. L. G. powder at 200 yards range. The gun was laid against the thin portion of the 48 ft. target, described by us last week in our article upon the previous series of experiments. This, it will be remembered, consists of an 8-in. plate, backed by 18 in. of teak, and a $\frac{3}{4}$-in. skin. The peculiarity of the Fingspong projectiles consists in their being made from a metal which is so soft that, although the head is cast in a chill, it can readily be turned afterwards. It would appear to be working out on a large scale the old experiment of shooting a candle through a deal board, for the theory of these projectiles is that they shall effect complete penetration without breaking up. This, we are informed by an impartial observer, they have done over and over again on the Continent; $10\frac{1}{2}$-in. and 9-in. shot having alike readily penetrated and passed through an 8-in. armor plate, coming out whole in the rear. This, however, they certainly did not do at Shoeburyness at their recent trials.

The first shot was fired with one of these solid chilled shot weighing 253 lbs. It entered the target at an angle of 45 deg. to the face of the plate, striking it 7 ft. 6 in. from the proper right end, and 15

in. from the bottom, being 5 ft. from the line of aim. The shot, which had missed both of the velocity screens, broke up, the head remaining in the hole. The rear of the target sustaining little or no damage. The erratic course of this shot was attributed partially to the gun being cold, no scaling charge having been fired, and partially to the softness of the studs. Round No. 2 was therefore a repeat of No. 1, the projectile striking the target at a point 3 ft. 1 in. from the right proper end, and 5 in. from the top of the lower plate, being a deviation of 2 ft. 7 in. from the point aimed at. The shot effected total penetration, in which it was assisted by a previous shot hole, passing out in the rear through a smith's shop—which was, of course, empty—and breaking up. The point and several large fragments were found in the tramway some 50 yards to the rear of the target. A 9-in. Firth's steel shell, weighing 241 lbs., and filled with a bursting charge of $7\frac{3}{4}$ lbs. of powder, was then fired from the same gun. The projectile this time cleared the target altogether, passing over the top, and burying itself in the earth roof of an old casemate several yards to the rear without exploding. This result rendered it apparent that either the shot did not centre in the gun, or that the platform was not steady, and that the deviations of the Fingspong projectiles were due more to defects in the piece or platform than to softness in the metal of the studs.

At this stage the proceedings were varied by Col. Milward, who directed the trial of the picric powder to be made. This powder is of a bright yellow color, and is prepared from carbolic acid. Mr. Abel places it, as regards explosive effect, half way between gunpowder and gun-cotton. He states that it does not act injuriously on the metal of a gun when fired from it, and although not at present fitted for that use, a modification may hereafter be found which will answer the purpose. The first round, No. 4, in the consecutive order, was with a 9 in. large core Palliser shot, having a bursting charge of 4 lbs. of gunpowder in order to afforda comparison with the picric powder. The gun charge was 43 lbs. of R. L. G. powder as before, and the range 200 yards, the gun being laid against the thick portion of the target, which is composed of an 8-in. plate, 6 in. of teak a 5-in. plate, 6 in. of teak, and a $1\frac{1}{2}$-in. skin. The shot struck the lower plate 12 in. from the bottom and 4 ft. from the proper left end, effecting a penetration of 18.2 in. and bursting in the hole. The rear part of the shell was blown to the front, some of the fragments of the base flying back nearly to the gun. The next round was fired under precisely similar conditions to the last, with the exception that the bursting charge of the shell was 4 lbs. of picric powder. The results also were very similar, the shot striking the same plate 3 ft. 4 in. from the proper left, and 2 ft. 4 in. from the base. The head remained in the hole, effecting a total penetration of 17.5 in., the rear of the projectile and some of the picric powder being blown to the front. No conclusion could be arrived at from these two shots as to the relative values of picric powder and gunpowder, as the shots did not penetrate sufficiently far into the target for the charges to have any lateral effect upon the structure. It is probable that the charges were too sensitive, and burst a little too soon, thereby preventing further penetration of the shot. No doubt, by retarding explosion, the projectile would have a better penetration, and the burst would take place at the right moment with better effect. Be this as it may, we have at present no data whereon to base an estimate of the value of picric powder as a charge for shells.

The order of the programme was then resumed, and round No. 6 was a repeat of No. 3, rendered necessary by Firth's shell in the former round flying over the target. In the present case the shot grazed the ground 18 ft. from the face of the target, ricochetting on to the plate, there making an indent $15\frac{1}{2}$ in. long by 9 in. wide, and 3 in. deep, and breaking up. This result rendered another repeat necessary, and the projectile in No. 7 round struck the upper plate of the thin part of the target 12 ft. 7 in. from the proper right end, and 2 ft. 8 in. from the bottom of the plate. The shell burst in the wood backing, the point of the head projecting several inches through the rear skin. Although a considerable amount of damage was done to the rear, it is certain that that damage would have been much greater had the explosion been slightly retarded. A return was then made to the Fingspong metal, a cored—or rather a bored—shot being directed against the thin portion of the target. It struck the upper plate 11

ft. 9 in. from the proper right end, near the upper edge of the plate, and 2 ft. 9 in. from the line of fire, entering at an upward angle of about 45 deg. A penetration of about 12 in. was effected, the point remaining intact, but rebounding, with a large portion of the body attached to it, 5 ft. to the front. The projectile—so much as remained of it in one piece—was much cracked longitudinally, and was afterwards broken up by about a dozen blows from a heavy sledge hammer. This round decided the fate of the Fingspong projectiles, which, although made of splendid metal, did not in these samples reach the standard of the chilled projectiles at present turned out at Woolwich. The 9th round was with a 9-in. Firth's steel shell carrying a bursting charge of 7 lbs. 6 oz. of powder in two bags. The shell struck the thin portion of the target 1 ft. 7 in. from the proper left of the upper plate, and 1 ft. 9 in. from the top, bursting in the wood backing, which it set on fire, and doing considerable damage to the rear portion of the structure. A heavy piece of the shell was thrown to the rear of the target, which bore witness to the great destructive effects of the projectile, the teak backing having a large hole blown upwards above the point of explosion, opening to the top of the works. In the last few rounds with the 9 in. gun, the shots were delivered well on to the points of aim, so that the gun appeared to have warmed to its work, although the earlier shots were much more wild than, under the circumstances, they ought to have been. The fouling of the gun probably aided in insuring the correctness of the latter results.

The splendid 11-in. Woolwich gun was then brought into play with a Palliser shell filled wlth a bursting charge of 9 lbs. of powder. The gun was laid to the thick portion of the target at 200 yards range, and was fired with a charge of 85 lbs. of pebble powder. The projectile had a velocity of 1,262 ft., and struck the lower plate 18 in. from the top edge, and 3 ft. 6 in. from the proper right end. It passed clean through, bursting splendidly in the wood backing, and yet the base plug and portions of the shell were driven through far to the rear. In the 11th and final round, the gun charge was reduced to 75 lbs. of pebble powder, and a Palliser cored shot charged with 6 lbs. of powder. The velocity was 1,187 ft., and the projectile struck the upper plate of the thick portion of the target 16.5 in. from the bottom edge, and 19 ft. from the proper left end of the plate. The shell went clean through the target, bursting apparently in its passage through the skin. The results were eminently satisfactory, and fully maintained the character of this excellent weapon and of the projectiles.

The results of the day's proceedings served to establish three things mainly: Firstly, the inferiority of the Fingspong projectiles to those turned out at Woolwich ; secondly, the exceptionally fine character for the Firth steel shells ; and thirdly, the subjection of the targets to the guns once more. There is one thing to be said for the 11-in. gun, and that is that it is properly mounted on an iron carriage and slide, which its 9-in. companion is not. This may in some measure account for the wild shooting of the latter at first. But, however this may be, it is to be hoped that steps may be taken to insure a proper mount for every experimental gun, so that fair and accurate results may be obtained. It is a curious fact that the 11-in. gun has been greatly decried in the past; no one appeared to have any confidence in it, notwithstanding that a number of Blakely guns of that calibre were made years since, and have done good service in Peru. But now that the 11-in. gun has asserted its position, it is very probable that a strong tide of military opinion will set in, in its favor.

THE manufacture of casks is carried on on a large scale at Gallipoli, and in the 5 principal manufactories in that town it gives employment to upwards of 400 persons. The casks made at Gallipoli are in great demand throughout the Mediterranean, as from their excellent construction they are adapted for containing oil. During the past year (1869), besides those required for the exportation of 29,664 salmas of oil from this port, 92,428 salmas of empty casks were exported to the following places by 125 vessels :—To the Italian ports, 42,727 salmas ; 1,655 to Trieste ; 22,105 to the Ionian Islands ; 9,625 to Smyrna ; 6,987 to Metelino ; 5,382 to Candia; 1,822 to Calamata; 1,048 to Adramiti ; and 3,147 to the various other ports on the Mediterranean.

TRANSMISSION THROUGH PNEUMATIC TUBES.

From "Journal of the Telegraph."

The writer having been employed in designing the extension of a pneumatic dispatch line, in which some heavy gradients were unavoidable, it became necessary to ascertain by calculation the steepest gradient that could be employed, so as to obtain a sufficient carrying capacity in the new section of the line under given conditions of engine power and of length. Almost every text-book and paper on the velocity of gases in pipes, gave a different formula, and the author therefore found it necessary to attempt to construct a convenient expression for the speeds of carriers of given weight and friction, under various conditions of pressure, gradients, and dimensions of tube. The problem of a pneumatic system is simply this: To make a given quantity of air expand from one pressure to another in such a way as to return a fair equivalent of the work expended in compressing it. It is obviously impossible to regain the full equivalent of the work, because the compression is attended with the liberation of heat, which is dissipated and practically lost. Therefore, in designing a pneumatic system, the first thing is to contrive means of compressing the air as economically as possible; and, in the second place, to get back the available mechanical effort stored up in the compressed air, irrespectively of the work employed in compressing and examining it. The writer considers that small pneumatic tubes may be worked more profitably than large ones. The great convenience of and the practical facilities for working small letter-carrying tubes have been amply proved by the extensive systems already laid down in Paris, Berlin, London, and other towns, as adjuncts to the telegraph services. Tubes of somewhat larger diameter would undoubtedly work satisfactorily. Even still larger tubes, of a moderate length, might also be found useful for a variety of special applications. But the author does not believe that a pneumatic line working through a long tunnel could, for passenger traffic, ever compete in point of economy, with locomotive railways. A pneumatic railway is essentially a rope railway. Its rope is elastic, it is true, but it is not light. Every yard run of it, in a tunnel large enough to carry passengers, would weigh more than ¼ cwt. And it is rope, too, which has to be moved against considerable friction, and in being compressed and moved wastes power by its liberation of heat. In a pneumatic tunnel, such as that proposed between England and France, in order to move a goods train of 250 tons through at the rate of 25 miles an hour, it would be necessary to employ simultaneously a pressure of 1½ lbs. per sq. in. at one end, and a vacuum of 1½ lbs. per sq. in. at the other. The mechanical effect obtained of these combined—pressure and vacuum—would be consumed as follows:

In accelerating the air . .	29	millions of foot pounds
In accelerating the train .	12	
By friction of the air . .	5721	
By friction of the train . .	330	

The resistance of the air, therefore, upon the walls of the tunnel would alone amount to 93 per cent. of the total mechanical effect employable for the transmission; while the really useful work would be only about 5½ per cent. of it. And to compress and exhaust the air to supply these items of expenditure of mechanical effect, engines would have to exert over 2,000-horse power at each end during the transmission, even on the supposition that the blowing machinery returned an equivalent of mechanical effect such as has never yet been obtained. This would not be an economical way of burning coals.

The report of the Brighton Railway, presented recently, shows that, reckoning increase of traffic and diminution of working expenses, the result of the half-year has been £52,344 better than that of the corresponding half of 1870, enabling all preference interest to be met and a dividend of 7s. 6d. per cent. to be paid on the ordinary stock, which will absorb £25,649, and leave £2,048. At the same time many improvements have been effected out of current receipts, and as the autumn half-year generally yields about £100,000 more traffic than the first half-year, a hope is expressed that for the whole of 1871 a satisfactory dividend will be realized.

DISINFECTANTS.

From "The Engineer."

Forewarned is forearmed, says the proverb. There seems no reason to doubt that Asiatic cholera is travelling westward on its beaten track, wherefore it behooves us to put our houses in order, so that the enemy may not take us unawares. Since 1832, when the cholera visited us, a desolating mystery, a large stock of experience has been gained ; and although medical men, so far from having discovered a specific against it, are not even in accord as to its pathology or treatment, yet a large fund of experience has been gained as to the conditions under which the Asiatic scourge propagates itself from locality to locality. Since 1832 the cardinal point has been determined that cholera, unlike the plague and the small-pox—the latter having much in common with the plague—is not a contagious disease. It cannot be propagated by mere contact ; cannot even be disseminated, according to the major weight of authority, by breathing the air of cholera-infected places. The sole condition of its progress seems to be the taking in by the stomach of an organic germ, itself a cholera development. Hence, according to this theory—nay, more than theory, from our point of view an established fact—the restraining of cholera mainly resolves itself into the destruction of this organic germ by one or more things belonging to the repertory of disinfectants. Now it is of first importance to have a clear notion of the nature and agency of disinfectants, bodies which, though designated by one common name, are not equally applicable under all circumstances. Certain disinfectants, though potent as germ destroyers, have a limited application in that way, being themselves poisonous. Some destroy metal work, and therefore cannot well be used for the purification of metallic valvular drains. Some, though efficient, do not admit of use because of their too great expense. Owing to this diverse character it will be well worth while to run through the list of popular disinfectants, specifying the conditions and limits of utility of each. The most in repute of popular disinfectants is chloride of lime, of which the active or disinfective principle is chlorine. The excellence of this material consists in its evolving chlorine so gradually as to be not incompatible with health; for chlorine itself in a pure or concentrated state, or even when considerably diluted, is rapidly destructive of human life when breathed. If the proposition be to destroy the germs of communicable disease in an uninhabited apartment, no agent can compare with chlorine, easily procurable by adding oil of vitriol enough to convert into thin paste a mixture of black manganese with common salt, in equal parts. The mixture should be effected in an earthenware pan enveloped by hot sand, set in the middle of the room to be disinfected, care being taken to depart and close the door before any of the fumes are breathed. Chlorine is a powerful bleaching agent, hence all dyed and printed fabrics, the colors of which it may be desired to preserve, should be previously removed from the chamber operated on, if, indeed, the protection of such things under such circumstances be desired in any case, a precaution not to be sanctioned by considerations of sanitary science. Chloride of lime solution forms an admirable bath for the disinfection of cotton and linen fabrics ; but when employed for this purpose soap should never be used.

Next in importance to chlorine and chloride of lime comes the permanganate of potash, the solution of which is popularly known as "Condy's fluid." This disinfectant is very effective under certain known conditions of its efficacy. It is not, like chlorine, volatile; hence it cannot pervade a chamber and search out and attack organic matters, which, therefore, have to be brought into contact with it. Under some conditions this is an advantage, as, for example, in an occupied sick-chamber, where the presence of chlorine, even in an attenuated form, as when slowly developed from chloride of lime, would seriously affect the breathing organs. The evil odors of a sick-room may be entirely destroyed by sprinkling the floor and walls with Condy's fluid, or, perhaps, more effectual still, by hanging rags saturated with this fluid on lines. Perhaps, however, the greatest disinfec-

tant value of the permanganate is referable to the facility with which it destroys organic matter present in water. This fluid itself is deep purple, a tint which immediately disappears when brought in contact with organic matters. Hence it follows that, if on adding a few drops of permanganate solution to a sample of water, the purple tint disappears, this is proof of the existence of organic matter ; and if the object be that of purifying water from such by the permanganate, the latter should be gradually added so long as decolorization ensues. The fumes of burning sulphur enjoy a certain disinfectant repute, but the utility of this agent, certainly inferior to chlorine, is limited by the same considerations that limit the utilization of chlorines. Sulphurous acid—and the fumes of burning sulphur are only that—is, however, of inestimable value as a specific disinfectant against such organic germs as result from certain varieties of fermentation. Sulphurous acid checks fermentation absolutely ; hence, when brought into contact with otherwise fermentable matter, the conditions for germ formation cannot arise. The repute in which carbolic acid is held as a disinfectant is great, but this agent, though powerful, is not without drawbacks. It is very poisonous when swallowed, and, accordingly, numerous accidents have arisen from accidentally swallowing it. The odor of carbolic acid, though to some not disagreeable, is too strong to be compatible with a wide range of domestic utilization, and its vapor is injurious to the eyes. Amongst the most recently introduced disinfectants is the the compound named chloralum, the active principle of which being chlorine, assimilates it in operation to chloride of lime.

Any notice of disinfectants would be imperfect that should fail to take cognizance of lime wash, one of the most common of disinfecting resources, and one so very much abused that, far from doing good, it is often injurious. About the power of quick-lime to destroy organic germs—indeed all organic matter—there can be no question, and the practice of covering walls and other broad surfaces with thin caustic lime paste is accordant with one of the best disinfective indications. Unfortunately in practice the so-called operation of lime washing is little else than a pretence. The London plasterer, at any rate, is rarely content to make his wash of lime and water alone, he uses a certain portion of tallow and size to give adhesion, and mixes whiting or chalk with the quick-lime to impart additional whiteness. The offensive odor of London lime-wash is too obvious for comment. This depends on the putrefaction of organic matter, the cause, we believe, of more harm than the actual lime can do good. Generally the presence of miasmatous infective matter is accompanied with an evil odor, but practice has demonstrated the possibility of the existence of disease germs without any odorous circumstance. The usual cause of evil smells, as in drains of houses, is the presence of sulphuretted hydrogen gas, an extremely poisonous compound, which, if frequently breathed, lowers the health standard and begets disease. For this reason sulphuretted hydrogen should always be kept under, for reasons independent of organic germs, and perhaps common green vitriol—sulphate of iron—is the very best substance for absorbing this gas. A pound of sulphate to a gallon of water are very good proportions, forming a liquid that admits of use in many instances when others would be inapplicable. For example, chloride of lime cannot be very extensively used in contact with metal surfaces without seriously affecting them. Thrown down the pipes of a closet, for example, it would soon destroy the fittings, whereas green vitriol has the advantage of being utilizable under these circumstances in any quantity without effecting the slightest disintegration.

On more than one occasion we have protested against the abuse of dust-bins. We believe them to be the *foci* of more disease-originating evil than the public would like to contemplate; and, cholera or no cholera, we hold that the free-and-easy way of allowing not only dust, but vegetable and animal organic matter to fester and putrefy there, is not worthy of a civilized people. If servants could only be induced to burn such *disjecta membra* of household refuse as bones, cabbage-stalks, lobster-shells, and the like, merely conveying the ashes of these to the dust-bin, a great sanitary point would be gained; and if, in addition, the heap were daily covered with a thin layer of chloride of lime, or even ordinary caustic lime, the

dust-heap evil—if not wholly done away with—would be reduced to a minimum. Having already touched upon the question of water supply, we shall only now add that filtration is not, in our opinion, effectual in freeing water from any but the grosser mechanical impurities. That the very best of filters can exercise any important chemical effect on water we do not believe, inasmuch as, of whatever material a filter is made, its chemical potency is soon exhausted.

TECHNICAL DICTIONARIES.

From "Engineering."

The "international" tendencies of the present day have not been without influence on the literature of the period, and accordingly we find that within the last few years several works have been put forward which may be classed under the general heading indicated by the title of this article. Pending the adoption of the universal language, which is, we devoutly hope, very far off, certain individuals, more or less qualified (generally less), have set themselves to compile vocabularies, giving the equivalents of technical terms in various languages. We do not propose to enter upon a regular review of any of these works, but intend simply to make a few suggestions for the benefit of authors who think they have a call to enter on the preparation of a Technical Dictionary.

The first and most important requisite of such a book is that it shall present a faithful list of the words in use at the time of publication, and not be overburdened with obsolete and erroneous terms belonging to a past generation. It is for this reason that all dictionaries which seek to recommend themselves as containing so many thousand "additional words" should be regarded with suspicion. It is quite true that obsolete words should appear in what we may call the "first place," for the benefit of those who may be reading old books. For instance, in a good English-German-French dictionary, we should expect to find the word "fire-engine," as denoting the machine now called a "steam-engine," of course with a note to prevent the unwary use of the word by a foreigner writing English. Even so late as 1793 a tract was published under the title of "Introduction to the art of making machines *vulgarly* called steam-engines," thus showing that the word "steam-engine" had by no means gained for itself admission into all circles at the end of the last century. It is, indeed, probable that "steam-engine" and "fire-engine" were used indifferently to denote the same thing for many years after that date. We should *not*, however, expect to find in the French part of our imaginary dictionary the word "fire-engine" given as an equivalent for *machine-à-vapeur*. Moreover, the author should be careful to point out, if he can, the subtle distinctions between such words as "road-steamer," "steam-carriage," "road-locomotive," and "traction-engine." It is here worth noting that "steamer" was once applied indifferently to machines for moving through the water and to those suitable only for locomotion on land. It was probably never used by authors in the latter sense, but the present writer well remembers hearing it applied to locomotives by country people many years ago. We have never yet seen a dictionary which attempted to discriminate between "mechanic," "mechanician," "mechanist," and "machinist." The first of these words has, in London, a local signification, by which it is made to include almost every one whose trade is mechanical; but we fancy that a bricklayer in the North of England would be rather surprised at being called a "mechanic." Again, "machinist" has, since the introduction of the sewing machine, obtained an entirely new meaning. It has also a special signification behind the scenes of a theatre. Similar varying shades of meaning also exist in French and German. For instance, one of the meanings of *mécanicien* is "engine-driver," and we occasionally see in newspaper accounts of French railway accidents that "the mechanician escaped unhurt." We may perhaps one day meet with a literal translation of *chauffeur*, the French designation of the driver's mate, the "stoker" or "fireman." After all, it would not be

so very foreign to the language, as the word still lingers here in that mysterious functionary in the Court of Chancery, whom it was once our privilege to behold in the flesh, we allude to "Mr. Deputy Chaff-wax," whose duty is to heat—*chauffer*—the wax for impressing documents with the Great Seal. However pedantic such an assertion may appear to the "practical man," we shall never have a technical dictionary worthy of the name, unless the compiler brings to his task a certain amount of etymological and philological skill. He must be prepared to notice the peculiar circumstances which influenced the technical terms in new branches of industry. Take an example. It is interesting to note that railways on their first introduction were intended to be a sort of modified "King's highway." All the old railway acts contain clauses providing for the running of private trains. The term "rail*road*" (now discarded here, but still in general use in the United States) shows this to a certain extent, and the analogy may be carried still further by the terms "driver," "guard," "coaches" (as the carriages are still called by the railway employés), and "wagons." Even so late as 1839 we find the author of a book on "Roads and Railroads, Vehicles and Modes of Travelling," saying: "There is a class of stage coaches (if the term be properly applied to them) which have come much into use within a few years; we mean those employed on the various railroads. These vehicles have never to make any of those sudden turns which are required on common roads .... some are shaped like private carriages."

As in general literature so in technical literature, it is entirely beyond the power of any dictionary maker to influence the use or disuse of any particular phrase or word. The dictionary of the French Academy is sufficient proof of this. It may also be said that a new word is never introduced by a dictionary; but when the necessity for it becomes very pressing it springs up mysteriously, and if it happens to suit the public taste, is straightway adopted into the language. "Telegram" is a case in point; but "Bessemerise," founded on the German "Bessemern," which signifies the carrying out of the Bessemer process, has scarcely survived its birth. The word "re-railing" in the sense of replacing a railway carriage on the rail after an accident, is vastly convenient, but has not been generally adopted. Again, we are not yet permitted to say, without a charge of using an Americanism, that two trains "collided." American writers are not troubled with the conservative scruples which hamper us with regard to the invention of new terms, and no German is ever at fault, in consequence of the marvellous facility with which compound words may be formed in that language. But as we have said before, it is not the province of the compiler of a technical dictionary to invent new words, a maxim which some would do well to bear in mind. In many works of this kind the authors appear to have thought that their task was ended when they had ransacked previous authors, good, bad, and indifferent, and simply arranged in order the words so obtained. No note is taken of the gradual change which all language is continually undergoing, and the most ridiculous blunders are propagated. They never seem to think that it is necessary to read modern authors of established reputation for the purpose of recording new words or old words used in a new sense. At the present day, when periodical literature occupies so prominent a position, it is obvious that this search must be made principally in the technical and scientific journals. If any one would only take the trouble to read over a translated article in a leading French or German periodical (he will have no difficulty whatever in finding one), and, with the English original before him, note the rendering of all the technicalities, we can promise him that they will be very different indeed to anything which he will find in the very latest and best technical dictionary. We venture, also, to call the attention of intending lexicographers to another profitable mine which has never been worked as it ought to be. We allude to illustrated trade circulars and price lists, such as Barras & Blackett's "Sheffield Standard List," or Appleby's "Illustrated Handbook of Machinery." By a comparison of these with foreign lists of a similar kind, an immense number of words might be obtained which have never found their way into any technical dictionary. We will venture to say that the advertisement columns of this very number contain at least fifty terms which an unfortunate translator might

seek for in vain in his favorite lexicon; or if he did find them, the majority of the renderings would be sure to belong to the last generation, or perhaps to no generation at all.

In the absence of any reliable technological dictionary the only resource left for a translator, when the context does not clearly indicate the meaning, is to read up the subject in a work written in the language from which he is translating. In this way one may generally succeed, with patience, in extracting the meaning even of the most cloudy German author, and that is saying a good deal. We say generally, because there are some cases in which no English equivalent exists, as, for instance, in metallurgical and other processes which are either quite new or are confined strictly to a particular locality. These are real difficulties out of which all existing dictionaries are unable to help us.

We have refrained from mentioning any dictionaries by name, but should our remarks meet the eye of any industrious compiler, we take the liberty of suggesting that he should discard at least $\frac{3}{4}$ths of the matter which he has accumulated from other authors. A careful revision of the remaining fourth, according to the principles we have laid down, will probably lead to a still further reduction of quantity, and to the improvement of the quality of his work. It should always be borne in mind that 100 words picked up in the workshop or from writers of authority are worth a 1,000 which simply embody the accumulated errors of dozens of ignorant compilers.

EXPLORATION OF THE TIBER.

From "The Builder."

One of the first reflections that occurred to many persons familiar with Italy, on hearing of the fall of the temporal power of the Pope as the master of Rome, was, Now, at length, the Tiber will be explored! It is not for the first time that the work has been attempted. The conviction is strong among Italians that treasures of art, of fabulous amount, have been cast into the turbid river on each successive capture or sack of Rome. Without counting the occasions on which extreme terror was caused in the city by the ravages of the Huns, under Attila, and by the final overthrow of the empire by Odoacer and the Heruli, the capture by Victor Emanuel in 1870—the 2,624th year of the city—was the ninth instance of a successful siege of the capital of Europe. Of these the first (under Brennus in the 365th year of the city), and the three preceding the Italian conquest, were all effected by the same nation, the warlike and restless inhabitants of Gaul. Of neither of these sieges, unless it be of that by the Constable Albert de Bourbon, in A. D 1547, which, indeed, was rather a Spanish than a French feat of arms, can we expect to find any memorial preserved beneath the waters of the Tiber. But on the more fatal occasions of the sack of Rome by Alaric, by Genseric, and by Totila, and possibly on that of the capture by the Greeks under Belisarius, the firm opinion of the Romans is, that despair sought to rob the barbarians of their prey by casting the treasures of the city into the Tiber.

The existence of so long established and firmly held tradition is ample justification for an attempt being made to solve the question. It will not be necessary to incur a very large outlay in the first instance, as a comparatively partial exploration will be enough to prove whether it is worth while to continue the operations on an exhaustive scale. We regard the problem as one of immense interest, although not one of which it is at all easy to anticipate the solution. The present era is distinguished by discoveries in human history, no less than in science. The ancient world is being interrogated, and has only commenced to speak, in an intelligible language, in reply. In Egypt, in Assyria, and in Palestine, a very large amount of positive information as to the history, art, and warlike and social habits of nations now swept from the earth, has been freely forthcoming. In Italy, it must, however, be remembered, the work of exploration is not new. The respect of the Italian peasant for the slightest memorial of *Antichita* can hardly be realized by persons so heedless of their own pre-his-

toric monuments as are the majority of Englishmen. The pride of the Roman in his name and ancestry is enchanced by the high price always commanded by any relics worthy of note. Italy has been thrashed over in the search for coins, gems, statuettes, and terra-cotta lamps and vases. But the riches in the soil in these relics seem almost inexhaustible. The Count of Syracuse, the brother of King Ferdinand of Naples, added much to our knowledge of Roman antiquity, by his systematic exploration of tombs at Cumæ, and elsewhere. Apulia is very rich in remains, and has hitherto lain too remote from the influx of tourists to be by any means exhausted of its treasures. Terra-cotta funereal sculpture, of wonderful vigor and beauty, has been within the last year or two acquired by the South Kensington Museum from this part of Italy. The Government exercises a right over all treasure trove of this nature, and the general object of the law is, both to preserve all structural remains, and to prevent the removal from the country of any portable objects. Thus, in spite of the sloth and corruption of the administration, the *Museo Borbonico* at Naples has become enriched with some of the most exquisite remains of art that have anywhere escaped the ravages of time.

Apart from the architectural remains, which public and private taste alike respect throughout Italy, the recoverable relics of ancient art mainly consist of coins, gems, mosaic, terra-cotta lamps, vases, and statuettes, bronzes, and marbles. To these six classes of objects the operations at Pompeii have added the discovery of fresco paintings. In addition to this, specimens of food, tools, armor, requisites for the toilette, and personal ornaments of all kinds, have been found in the Campanian cities, and his Royal Highness the Count of Syracuse was in possession of a Roman lady's work-box, made in the first century of the Christian era. Frescoes and mosaics have been chiefly discovered at Pompeii, as the gradual induration of the volcanic ash which buried this city has not proved destructive to ornamentation on walls or floors. On the other hand, bronzes have been, for the most part, much corroded by long contact with the sulphureous tufa. The most perfect and uninjured bronzes have been found at Herculaneum, where the hot lava, pouring round the metal it encountered in its course, has enclosed it in a matrix impenetrable to atmospheric influences, and preserved it in all the freshness of its early state.

With regard to the surmised treasures of the Tiber two questions occur. First, is it true that so much and so many of the art-treasures of Rome have been thrown into the river; and then, if so, in what state of preservation may they be expected to exist? It is clear that a satisfactory solution can be given to these questions by the operations of the engineer alone.

We may, however, form some idea of what we should seek. Paintings, for instance, which are, from their rarity and other causes, the most interesting relics of antiquity, are here utterly out of the question. The same may be said of mosaics, except in the case of such small objects as fibulæ, or perhaps plaques. Marble and bronze statues are hoped for. In addition to the difficulty that would be experienced, at times when people were principally concerned in saving their own lives, in removing massive and heavy objects of this kind from their stations—and that not for the purpose of actual preservation, but from a questionable kind of art enthusiam, or even spite—the effect of the water of the Tiber, or the yellow mud which it rolls down, on either marble or bronze, during a period of more than 1,000 years, is not to be despised. The waters of the Italian rivers are often charged with salts of volcanic origin, none more so than some that are sparkling to the eye and soft to the touch and taste. A period of 50 years has been enough to eat away a great portion of the iron-work of vessels sunk in the Seine, leaving the remainder in the state of silver-like threads of great purity and beauty, but retaining little of the form of the object of which they composed a part. In the Seine, however, there is no trace of the sulphureous elements frequent in the Italian waters. Thus it will be only on the actual discovery of some uninjured work of ancient date, in marble or in bronze, that we shall be justified in looking with any confidence for more. The very first few days of a serious and well-ordered exploration will possess the utmost interest for all lovers of art.

For terra-cotta again, it is pretty clear that we shall look almost in vain. Quite imperishable as this material would be,

from chemical causes alone, its fragile texture, and the low intrinsic value of the articles of which it supplies the material, are such as to lead us to expect nothing but fragments of earthenware from the bed of the Tiber. Of course more is possible, but it is not, in our opinion, probable.

It remains, therefore, that the treasures which may most reasonably be expected from the careful exploration of the Tiber will be coins and gems. Nor can it be considered as improbable that ornaments of the person or of the habitation, composed of the more precious metals, will repay the toil. On gold, silver, and the hard stones of the agate and corundum families Father Tiber may try his teeth for a long time in vain. Objects of small size would be very likely in the first instance to be dropped or thrown into the river, and in the second place, to have sunk alone into its bed, and buried themselves from further disturbance.

For objects of this nature, of high intrinsic and artistic value, and requiring care like that of the diamond-washer to detect, it is clear that only a well-ordered and systematic search will be suitable. The Italians have great experience in research. The *scavi* at Pompeii have assumed the form of a regular industry, under the direction of the State. Nor have the engineers of Italy been slow to learn all that has been effected in the profession in England and in France; and in the execution of the Mount Cenis Tunnel they have far outstripped their French partners. But they are less experienced in dealing with the water. Their tideless seas, and, with few exceptions, riverless coasts, have afforded them no opportunities for such operations as are familiar to ourselves. Their one great river, long the tyrant and devastator of its fertile basin, has been tamed, so far as is yet effected, by Englishmen; as to whose treatment in the matter the less that is said the better. The experience gained in the canalization of the Po will be of little avail as to the exploration of the Tiber. The conditions in the latter case, are unique. It will be essential, in order to obtain any adequate support from this country, for something of our own large professional experience in tidal and submarine works, in river walling, and in sinking the foundations of river bridges, to be brought to bear upon the works attempted in the Tiber. On former occasions, when great interest was excited in this country on the subject, when money was forthcoming for the search, and when only the steady and stolid opposition of the Papal Government prevented the solution of this secular problem from being attained, it was taken as a matter of course that the works would be directed by English skill and energy. Italy has made enormous strides since that time in her mechanical excellence; but no men will be justified, in a matter of such European interest, in failing to avail themselves of the experience gained in the raising of the Royal George, in the bridging of the Tamar, the Medway, and the Thames, and in the recovery of Roman relics from the mud of the river Fleet.

In fact, it must not be doubted that for the exploration of the bed of the Tiber to be attempted with any satisfactory result, it must be confronted as a serious operation of the civil engineer. No peddling, no amateur work, no trusting to the chapter of accidents, can lead to success. The work must be undertaken under competent authority. Either the Italian Government must itself take it in hand, as in the case of the excavations of Pompeii, or it must give to the company or association undertaking the enterprise a definite and exclusive right, for a fixed period, to deal with an agreed portion of the Tiber. The proprietorship of objects recovered must be distinctly ceded to the company, any Government reservations or claims being renounced, or reduced to well-defined limits. Preliminaries being thus properly arranged, the next step will be to make such a thorough investigation of a measured area of the bed of the river, as may afford some basis for future calculations. This may be done by means which are perfectly familiar to English engineers, at small and definite cost, and with an exhaustive result. In case of failure, a second, and even a third exploration of spots selected in different parts of the channel would be proper. If the result confirm the sanguine expectations of the explorers, there will be no difficulty in raising the capital necessary for a proper inauguration of the enterprise upon a sound practical basis. If then such searches as we suggest, should prove unavailing, as we fear they might, we should recommend the abandonment of the design.

Should the preliminary investigations have the result of proving that Art relics of value are actually embedded in the mud of the Tiber, and that the chemical effect of the water has not proved so corrosive as to reduce bronze and marble to shapeless deformity, we shall have before us a very notable and important enterprise. If a long-lost chapter, or series of chapters, in the history of Rome may be thus regained, neither cost, nor toil, nor patience, must be spared in adding so precious an illustration to human knowledge. Above all, it will then become necessary that impatience and slovenly work should be avoided, and that Tiber, if put to the question, shall be made to yield up the entire truth. It is obvious that this can only be done by an operation of the most complete kind. The sanitary state of Rome will be materially affected by the proper regulation of the Tiber ; and questions of sewerage, drainage, and protection against the ravages of flood, will all demand proper forethought and skilled settlement. Any attempt to save expense in the first instance, or to dribble away time and money in successive potterings with sections of the Tiber, will involve failure. The objects which we conceive to be most likely to repay the toil of the explorers, are precisely those which nothing but a thorough and leisurely exploration can reveal. Working against time in the bed of a river subject to floods, and with the scene of operations only partially bared, or imperfectly protected, would yield but scanty result in the shape of gems, coins, or small articles of personal ornament. The extraction, uninjured, of large objects of sculpture or of architectural character, if met with, would be equally out of the question, unless the engineer of the undertaking has his work clear and open before him. A diversion, or series of diversions, of the stream will be a necessary feature of the case. It is unnecessary for us to come uncalled for into council, or to point out, unasked, the proper methods, either of making at once the cheapest and the most thorough preliminary search, or of uniting the various objects of sanitary improvement, and of provision for the discharge of flood-water. It is, indeed, possible that the Romans may choose to deal with their historic river after their own fashion. In such a case we shall have nothing to do but look on with interest, both at the engineering and at the archæological results. But in cases of this kind it is the usual custom of our continental friends to come to this country for money. Lovers of art in England have already been appealed to, to support the great enterprise of the exploration of the Tiber. It is to them that we speak, with all the earnestness which acquaintance with Italian life, and longer acquaintance with subaqueous and fluviatile operations, render natural, and, we hope, pardonable. It is quite possible for a considerable sum of money to be spent, not only uselessly but mischievously. For if the attempt be now made in any but the proper manner, the result will be the final abandonment of all the buried stores of Tiber, be they more or less. Let no Englishman, then, further the scheme in any way, unless he be assured as to the conditions under which it is to be carried out.

In a word, if in searching the bed of the Tiber we are not told once more, *Italia farà da se*, we have nothing to do, in this country, but look on with interest. If Italy comes to London for aid, that aid ought to be afforded only on the clear and distinct conditions to which we have referred. A definite Government concession, in which at least one English name is inserted, must be a *sine qua non*. Then, a plan of operations must be laid down by an English engineer, and faithfully carried out under his direction. In this case we shall be able, first to know what we are about, and then, if we decide to go on, to do so to certain good results. Rome will, in such case, be certain to benefit by the permanent effect of the river works carried out ; and it may possibly be the case that the museums of Europe will receive such additions to their stores as shall prove worthy companions to the Elgin and Phigaleian marbles in the British Museum, to the busts and statues of the Vatican, and to the exquisite *camei* and unrivalled bronzes of the Museo Borbonico at Naples.

The North Staffordshire Railway Company are raising funds for their Tunstall and Potteries loop lines, which they must complete by July, 1872, under a penalty of £50 a day thereafter.

LAKE SUPERIOR AND THE COPPER MINES.

From the "Boston Journal of Chemistry."

Lake Superior has always been to us one of the wonders of the world. Although it was discovered by the Jesuits before Lake Erie or Lake Michigan, a great portion of it still remains almost unknown and unexplored.

The white man has merely encroached on its southern and western shores, while the great country to the north of it still remains almost the *terra incognita* that it was when the Jesuits founded their lonely mission at the entrance to the "great sea water," the Gitchee Gumee of the Indians. There, at the beautiful Sault de Sainte Marie, the Mission bell still rings its matins and vespers, and the good Fathers may still be seen in the streets with their long gowns and broad hats. The Indians still fish in the rapids for their favorite white fish, holding, with the aid of a single paddle, their birch-bark canoes as motionless as a vessel at anchor, while the current seethes and boils around them. But the restless American has been at work here, and a broad, deep canal connects the water of the lake with the quiet river below the rapids. This was constructed by a company who received a land grant from the United States. The tonnage passing through this canal is every year becoming heavier, for it conveys the products of the vast iron mines near Marquette, and the copper mines of Keweenaw Point, and soon the vessels bringing the products of the new country opened by the Northern Pacific road will begin to pass down.

From the times of the earliest trappers, it has been known that there were great deposits of copper somewhere around Lake Superior, but the Indians, who were always willing enough to sell the copper, refused to tell of its whereabouts. And it is only within comparatively recent times that the mines have been opened and worked. A trip to these mines is an extremely pleasant excursion, and one that may combine a great deal of instruction with pleasure. Boats sail regularly several times a week from Buffalo, stopping at Detroit, and going up the lakes as far as Duluth. The best point, however, for seeing the copper business, is Houghton, on Portage Lake, as this is in the centre of the mining region.

Portage Lake is a curious sheet of water. It cuts Keweenaw Point almost in two, and formed a short cut for the Indians who travelled in their birch-bark canoes. They never ventured far from shore, and this inlet saved them many weary miles of paddling around the point. But, to make up for this, they had a "carry" of half a mile at the head of the lake, across to the west shore of the point; and from this the lake takes its name. The white man has improved on this again, by cutting a ship canal through this half mile of sand, and the largest steamers now pass where once the Indian wearily carried his canoe.

The mines lie on both sides of the lake near Houghton, and extend along the point, and westward toward Duluth. Some copper has also been found on the north shore of Lake Superior, but the principal deposits seem to be those of Keweenaw Point. The road from Houghton to Eagle River passes by some of the most interesting of these mines, and, among them, the Calumet Cliff and Phœnix. This latter mine is somewhat celebrated, as being in the same predicament as the man who bought the elephant. A mass of copper was struck some years ago, which has been estimated to weigh more than 350 tons. It is pure metallic copper, in one single piece; and the question was, What to do with it? They could not raise it in a single lump, and it was so compact that they could not blast it. They at last resorted to drilling off piece after piece; but this cost almost as much as the copper is worth. Nearly the whole of the copper mined here is found in the state of metal, and only needs to be smelted to free it from the rock, and fit it for use.

The Cliff mine is one of the most interesting, as it penetrates deeper into the earth than any other mine in America. We selected this mine for examination, partly from this reason, and partly because it was one of the best supplied with labor-saving appliances in the region.

It is an old saying, that when you are

in Rome you must do as the Romans do; and when you go into mines you must do as the miners do. So we took off our clothes, and arrayed ourselves in the coarse canvas apparel of the miners. It must be confessed it did not improve the appearance of the party. Each of us was provided with a coarse canvas hat, furnished with a pad inside to protect the head from falling fragments of rock, and, on the outside, with a lump of clay in which to carry our candle. Thus equipped, we commenced our descent. A miner led the way, followed by the party, while another miner closed the procession, in order that there might be no stragglers. The descent for the first 750 ft. was comparatively easy, as we went down on the "man engine," which is a curious affair, made expressly for conveying the men to and from their work. Two beams of wood, a foot square, and 750 ft. long, are suspended alongside of each other at the distance of about a foot. These beams are so connected with a walking beam, that they have a perpendicular motion of 10 ft. At distances of 10 ft. apart are fastened foot-boards, on which a man can stand, while 4 or 5 ft. above the foot-board is an iron handle, which he can grasp. When a man wishes to descend, he steps upon the foot-board which is at the top of the shaft; he is then lowered 10 ft. by the motion of the beam, and finds himself opposite a foot-board on the other beam, which is then at its highest point; he steps across to that board, which then commences its descent, while the one he has just left is ascending. When the second beam reaches its lowest point, the first is again at its highest, and he steps back to another foot-board on the first, which is then lowered in its turn. This process is kept up until he has gone down as far as he wishes, when he steps from the beam into a gallery.

Our party all safely accomplished the descent, notwithstanding the loss of a candle or two, which went flaming down into the depths below us. It is a dangerous piece of machinery, however, and a year seldom passes without some fatal accident. The miner makes a mis-step in the dark, and is picked up a shapeless mass from the bottom of the shaft. After leaving the "man engine," we walked some distance along a gallery, and then began the real work of the descent; for it was yet nearly 500 ft., or 80 fathoms, as the captain of the mine expressed it, down to where the men were at work. So we still kept on, down over ladders fastened to the rock, the wooden rounds being sometimes almost worn through, at other times gone altogether; while here and there one would be replaced by an old drill. But at last we found ourselves among the miners. Now and then, we would be startled by the dull thud of an explosion, that told us they were blasting in other parts of the mine. We were introduced to the captain of the mine, who kindly offered to explain to us the whole process of mining. The vein of copper-bearing rock varies here in thickness from an inch to about 2 ft. A shaft is first sunk twelve fathoms deep, which may, or may not, be on the vein; in the latter case, a horizontal drift is extended until it strikes the vein. Galleries are then driven in both directions along the vein, which are called the *levels*. The mine is now ready for work, or *stoping*, as it is called. This is commenced by working away the top of the level, until it is about 10 ft. high, the men standing on the fallen rock to do the work. They first break away the rock, and having thus exposed a large surface of the vein, this is taken out. After they have thus got to some distance above the floor of the level, heavy timbers are put across from wall to wall, and on these are laid others, lengthwise of the level. They then begin work again, throwing the rock on these timbers, and the copper upon the top of the rock. Openings are left at intervals of every 200 ft. in the timber roofs of the galleries, which are framed around with heavy timbers, in the same way that log-houses are built; these are called *mills*, and serve to conduct the ore to the level below, from whence it is removed in cars to the main shaft. This process of working obviates the necessity of raising much rock to the surface.

After spending an hour or two watching the miners at their work, we prepared to ascend to daylight once more, after securing specimens of copper as souvenirs of our visit. The copper looked just as bright and fresh as if it had been burnished. The pieces varied in size from grains of sand to masses that would weigh 50 or 60 lbs.

The ascent was far more tiresome than the descent, and we were glad when we

stood once more at the foot of the "man engine." This brought us quickly to the surface. After changing our clothes, we proceeded to look after the copper that had already been brought up. We found that it was assorted into two sizes, at this mine, called respectively *barrel* and *stamp* work. The barrel work included pieces that were so large that they could be readily sorted out by hand, and packed at once in barrels. The stamp work, or *metal*, was composed of rock and copper, so thoroughly intermingled that it was impossible to pick out the copper by hand.

This was taken at once to the *stamps.* These vary in form, from the simple Cornish stamp—which is a bar of wood or iron, furnished at its lower end with a heavy shoe of cast iron, and having, near its upper extrêmity, a lug which engages in a tooth placed on a revolving shaft, like that of a trip hammer—to the highly complicated steam hammer. But they all answer the same object—that is, to reduce the ore and rock to a fine state of division. As fast as it becomes sufficiently fine to pass through the screen in front of the stamps, it is carried off by the stream of water that is constantly flowing through them. The further separation of the ore and copper is now effected, on the principle that if you agitate two substances together in water, the one having the greater specific gravity will sink to the bottom, while the lighter will be carried away by the stream. Many curious and interesting devices have been invented for this separation, but they all depend on this same principle. By continuing this operation long enough, the ore is at last obtained almost entirely free from rock. It is then packed into barrels, and is ready to forward to the smelting works; for although it is now nearly pure copper, it is in too finely divided a state to be of any practical use.

A small amount of native silver is also obtained in these mines, but the most of it finds its way into the pockets of the workmen. Lake Superior copper is the purest that is mined in the world, the only impurity being a trace of silver.

At the smelting works, which we visited at Detroit, on our way up the Lakes, all the complicated processes of the Swansea (England) works are dispensed with.

The copper, when it comes to the works, is already in the metallic state, and only requires to be melted. We found there, in addition to the barrel copper and stamp work, another description of ore known as *mass.* This consisted of huge masses of copper, some of them weighing 8 or 10 tons. The furnaces used are reverberatory, and resemble those in iron works, except that the top is movable, in order to introduce the mass copper. After the copper is melted, it is stirred with green wood poles, to reduce the oxide formed during the melting, which would, if allowed to remain, make the copper brittle. It is then dipped out in iron ladles, and run into ingot moulds. Notwithstanding the great excellence of the Lake Superior copper, it can only compete with that of foreign manufacture, by reason of the excessive duties levied on all imported into the country. The ore can be taken from Chili to Swansea, reduced, and brought to this country, at a lower rate than that for which the mine owners on Lake Superior can afford to work.

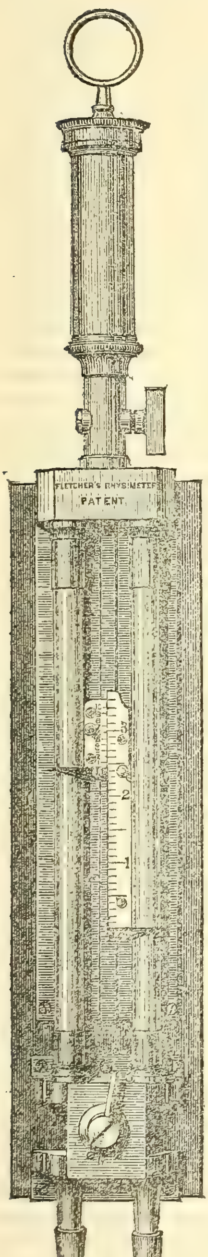
An additional amount of traffic was expected to accrue on the Dunaburg and Witepsk Railway line during the present year by the opening of adjoining lines, of which that from Witepsk *via* Smolensk to Moscow would be the most important, and was to be opened for traffic within a few months. In view of the increase of traffic which had already occurred, and which was further anticipated, the Directors have at the formal requisition of the Imperial Government made a considerable addition to the existing rolling stock, nearly the whole of which has been delivered on the line. During the past year the railway has been inspected by the Government inspector, whose report is most favorable as regards the state of the works and the mode in which the traffic generally is carried out.

Three new stations on the City and Suburban line of the Midland Railway were opened lately for public traffic:—The first from London is at Child's-hill and Cricklewood, to which 15 trains will run to and from all stations on the Metropolitan Railway; the next at the Welsh Harp, Hendon, to accommodate the pleasure and fishing parties visiting that spot; and the next at Flitwick, 2 stations on the London side of Bedford.

THE RHYSIMETER.*

By A. E. FLETCHER, F. C. S.

From "Engineering."



The principle on which this instrument is constructed resembles that of the anemometer, recently brought into notice by Mr. Fletcher, by which he is able to measure the speed of hot air, flame, and smoke, contaminated with dust or corrosive vapors, as met with in furnace flues and factory chimneys. Both in the anemometer and in the rhysimeter, the impact force of the current, and also its tendency to induce a current parallel with itself, are measured, and made to become indicators of the force and velocity of the stream.

The apparatus is very simple. A compound tube with 2 orifices at the bottom, one of which faces the source of the current, while the other faces the opposite direction, is held in the stream, and communicates by tubes with the indicator where the pressure is measured by colums of ether, water, or mercury, according to the circumstances of the case. When used to measure the velocity of a brook or open stream of water, the speed at any depth or at any portion of its surface can be separately estimated.

For taking the speed of water in pipes it is only necessary that there should be suitable cocks screwed into the pipes at the required places; through these the "speed-tube" of the rhysimeter passes without allowing any escape of water, whatever may be the pressure.

A still more important application of the instrument is to measuring the speed of ships. Here the speed-tube pierces the bottom or side of the ship, and projects a few inches into the water outside. The indicator may be in the captain's cabin. It resembles in size and appearance a barometer. In it a column of mercury indicates continually the speed of the ship. The full effect of the velocity is imparted to the mercury, without loss by friction or otherwise, so that the indication must always be absolutely correct. The instrument may be made self-registering, showing by a dial the total number of knots the ship has run since she left port, and marking on a sheet of paper the speed attained at every portion of the time. This permanent register may, in many cases, be of the greatest value.

The rhysimeter is already fixed on board some of the large mail steamers running from Liverpool to the United States and Canada, and has proved itself to be of the greatest value. It entirely supersedes the crude process of throwing the log, since it indicates, by simple inspection the exact speed of the ship in any weather.

The paper was illustrated by diagrams, and by tables showing the velocities in knots per hour, or in feet per second, for the various heights of the columns of water or mercury. Several handsome specimens of different forms of the rhysimeter were exhibited.

* An instrument for indicating the velocity of flowing liquids, and for measuring the speed of ships through water. Abstract of a paper read before the British Association.

In 1720 porcelain factories were erected in Vienna, in 1751 in Berlin, in 1755 near Munich, in 1765 in Sèvres, France, where the most beautiful porcelain ware of the whole has since been produced; in 1795 in St. Petersburg, Russia, in 1720 in Copenhagen, at a still later date in England, and in 1830 near New York city.

THE DOME IN POINTED ARCHITECTURE.

From "The Building News."

Amongst the small and unfashionable minority who look on Gothic principles, not as articles of faith transcending reason and demanding absolute and unquestioning obedience, but simply as rules laid down by the human intellect of one age, and capable of being revised or improved by that of another, it has long been a question why they should not be applied to domical construction. It may perhaps be answered that the use of the dome would imply the abandonment of all the mediæval features which had their origin in the cross vault, such as the buttress, the pointed arch, and perhaps even the gable. On examination, however, this position will, we think, prove more plausible than true. Even as regards the buttress, we doubt it. In a polygonal dome, with ribs at the angles, the main thrusts may certainly be connected into points and resisted by buttresses; while even in a hemispherical one, the same end might be gained by a skilful use of leaning arches. As to the pointed arch, however, the case is still plainer. It is no question of theory here; the pointed arch and the circular dome have been, as a matter of fact, combined in more styles than one. Just by way of calling attention to the subject, we will notice a few instances of their combination.

The earliest in point of time are probably those supplied by the Saracenic architecture of Egypt, and the best known examples are the mosques and tombs at Cairo. Amongst these may be found domes either circular or pointed in section, used, in each case, sometimes with round and sometimes with pointed arches. At the Barkauk Mosque, Cairo, both domes and arches are of the latter class, the points, however, being obtuse, and only just perceptible. The great dome, as usual, is considerably stilted, and its tambour, or upright face, is pierced by a range of lights. As usual, too, it is completely visible on the exterior, for the Mahometan builders, unlike the Romanesque ones, did not enclose their domes in a tower to serve as abutment. They so constructed them as to stand alone, thinning and lightening them towards the top, and weighting them near the base, so that even after their supporting walls are rent and decayed, some of them still stand as perfect as if they had been hollowed from one vast block of stone. Their base is usually square, and the transition from the rectangular to the circular plan is managed in several different ways. Externally, the square is often brought into an octagon, by sloping broaches, like magnified chamfer stops; but these, instead of being mere weatherings, as in a Gothic spire, are more frequently formed by a series of bold mouldings. On this type there are several variations at the tombs of the Caliphs, a mile or two from the city of Cairo. A different type, also common, is found at the Mosque of Hassan, and in this the square is carried up without alteration, and finished with an elaborate cornice; but, whichever plan is adopted, the dome rises clear of the summit. Very often it has no abutment whatever beyond the material contained in its own thickness. This, at the Barkauk Mosque, is about 2 ft. 6 in. in the tambour, or upright cylindrical portion below the springing of the curve. The wall of the square area beneath, at the same place, is not less than 6 ft. thick, and if it received the direct thrust of the dome, would be amply strong enough to counteract it. But the point at which, according to all ordinary calculations, this thrust tends to operate is many feet higher up. It is considerably above even the line or springing at which the curve commences; and yet even between the springing and the thick wall there is almost always, in these Egyptian buildings, a long stilt or upright surface, perforated by a range of windows. How these domes contrive to stand, and especially how some of them outlast the partial ruin of their supporting walls, is therefore in part a mystery. It certainly cannot be explained on ordinary theories of equilibration, but probably depends on the jointing of the stone, the skilfulness of the workmanship, and especially the tenacity of the connecting cement. At any rate, the durability of these buildings, some of them little less than a thousand years old, in a country where earthquakes are neither so rare nor so slight as they

are in our own, says much for the strength of domical construction. It might have puzzled the ablest of Gothic masons to raise a wide cross vault, with no abutments, on four or five yards of thin upright wall, and had the feat been accomplished, we question if it would have remained, even under the most favorable conditions, for modern eyes to see. The great dome at the Mosque of Hassan is about 70 ft. in diameter internally, and though in this instance the tambour is somewhat thickened by a complicated system of offsets, the addition is certainly not enough to render it stable by the mere effect of gravity. Of course, none of these domes had a cupola on the top, to weight them in the one place where of all places weight most needs to be avoided. They have not (or at least most of them have not) even a horizontal crown. They are slightly pointed in section, and turn up, on the outside, into a delicate ogee, ending in a bronze finial. The largest of the mosque domes, however, are not those which are most closely connected with our subject. Springing from a square area enclosed by walls, they do not illustrate, so well as some of the smaller ones, the use of domes in conjunction with arches. Such arches as are connected with them are naturally those of a secondary class, and of a span no greater than that of an ordinary door or window. But there are other domes to be found in these Mahometan works which have a vital and structural connection with arches, being supported by them entirely, and being connected with them, as in Byzantine works, by domical pendentives. The difference is, that in the Greek churches the arches are semicircular; in the Egyptian mosques they are as frequently pointed. This is the case, for instance, in the sanctuary of the Barkauk Mosque, where each dome rests on four piers, and is carried by four pointed pier arches. There is no string-course, and no difference of curvature, above their summits; the same dome which spans the area is continued down to the springing to form pendentives. The effect, though apparently artless, is very pleasing; the work is substantially done in the most unpretending way, and this simple style of construction has a grace and repose which are rarely found amidst the complicated groin ribs of the later Gothic.

Almost the same combination which prevailed in the edifices of mediæval Cairo still finds favor in those of modern Persia. There, too, the pointed arch and the dome are used together, though the curve either of one or both is generally compound, instead of being simple. The four-centred arch, in fact, has been almost universal there, until the upper part of the curve, growing flatter by degrees, has become absolutely straight, and the arch has become an angular one, with merely the haunches rounded. We do not mention this peculiarity to recommend it, for though compound arches are often convenient, they are rarely beautiful. The influence of custom is needed before we can even appreciate the work in which they exist, and allow for the real excellences which may exist even under this strange and unprepossessing disguise. The Persian architecture of the last three or four centuries shows in abundance the faults of a decaying style. It is "late" and "debased" in the same sense in which our own Tudor architecture is so; but, like it, it contains some magnificent and suggestive ideas for those who can distinguish an idea from the mode in which it may happen to be expressed. Nothing which it contains, however, seems more suggestive than its combinations of domes and arches. Of the former, some, though not many, have the plain pointed profile, as in certain parts of the Great Mosque of Mesjid-i-chah, at Ispahan. Here, for instance, is an apartment square on plan which is brought into an octagon above by four-centred arches spanning the angles, and upon these is placed a dome differing little in section from the principal ones at Cairo. The Pavilion of the Eight Gates of Paradise, Ispahan, in spite of its faults of style, is a work of striking beauty. It is octagonal, with the oblique faces of the octagon considerably narrower than the rest. Each of the longer ones is open to give entrance, and is spanned by a great four-centred arch. A passage of the same width leads from each archway to the exterior, forming, in fact, a corridor roofed by transverse ribs similar to the arch. But though there are four great archways leading into the apartment, they are not all alike. Two opposite to each other, are lofty enough to cut into the dome which spans the interior; the other two are only half as high,

and have a gallery above them. Over this gallery, however, the arches are repeated, springing from and rising to the same levels as the two loftier ones, while the diagonal faces are widened out by other arches, so that the lowest point of the dome may be considered as resting on a symmetrical octagon. The dome itself is a wonderful specimen of corbelling over and honeycombing; there is scarcely an inch of flat surface about it, and no description unaccompanied by views can convey any notion of its appearance. It is lighted from above, in a striking and effective way, by a circular lantern opening into a large ring near the summit. The bazaar of the ta lors, Ispahan, is very similar to this in arrangement, but much simpler in detail. It illustrates what is one of the peculiarities of Persian dome construction—namely, that the pendentives do not always stop at the apex of the supporting arches. On the contrary, they often continue to rise, and to converge inwardly for some distance beyond, so that the dome which is planted on them, instead of corresponding on plan to a circle touching the inner faces of the walls, is much smaller, and sometimes not more than two-thirds or even half the size. In the bazaar at Kacham, Persia, there are some remarkable applications of the pointed dome. It seems, in fact, to have been used in all sorts of situations, treated with the greatest freedom, made to bend and adapt itself to almost every shape and use for which a roof covering could be required. Thus we not only see domes on octagons and irregularly canted squares, but, in the great hall of the bazaar last referred to, even on an oblong more than twice as long as it is wide. Practically this is covered by three domes side by side, but there are no great transverse arches to separate and support them. There are mere mitre lines or arrises where one dome intersects with another, and even these are so faintly marked that they would scarcely show in an outline section. From all these and many other instances one fact is clear, that the Persian builders found the combination of domes and pointed arches a thoroughly practical and useful one, capable of being applied to the most various and widely-differing circumstances. They thoroughly mastered it in all its variations, and though, unfortunately, they worked in a degenerate and decaying style, they have done quite enough to show of what admirable results the system is capable.

Should any one think it a fault in the combination under notice that it was originated by Mahometans and misbelievers, we may remind them of a more orthodox application amongst the churches of Southern France. S. Front, Perigueux, and the long list of ancient buildings which are closely related to it, show the same type in a form perhaps better fitted for our instruction. Why, before the origin of the Gothic styles, these buildings came to exhibit pointed arches, is a question perhaps hardly yet decided. Mr. Fergusson has made the important suggestion, that in this early instance, as well as in the later, and far more familiar Gothic one, the form was introduced for structural reasons. It has at any rate structural advantages for the purpose; and in connection with the dome, too, it has great artistic merits. Roughly and barely as it is sketched out in these early examples, a more beautiful combination of lines can scarcely be found. If we want a new and untouched basis for modern art, here it is. Even with no ornament at all it is surpassingly graceful. The mere form and shadow of a dome on pointed arches are enough to constitute an admirable design by themselves; they do not ask for decoration to make them passable. Yet, on the contrary, they do not shrink from it. There is no better field for wall painting and mosaic than these grand unbroken surfaces. They will not attract the third-rate ornamentist, the man who relies on tracery and trash to make his designs go down. But they will commend themselves to the truly practical one, who aims at fulfilling modern requirements, and fulfilling them in a permanent and lasting style. If we want to throw our churches open and fit them for modern uses, the dome has everything to recommend it, for by the use of domes it is always possible to have wide spans and few obstructions. If we want to make them dignified and ornamental, the dome will be of equal service; no permanent covering is so cheap, so easily constructed, or so strong. If we want, in short, to develop an architecture of our own instead of repeating the architecture of others, to explore a new mine of treasure instead of groping

in the half-exhausted workings of the Middle Ages, we shall do well to turn our attention to the dome in combination with the pointed arch.

THE CAUSE OF LOW BAROMETER IN THE POLAR REGIONS AND IN THE CENTRAL PART OF CYCLONES.

By WILLIAM FERREL, Cambridge, Mass.

From "Nature."

In none of the treatises on Meteorology or Physical Geography is there to be found any satisfactory explanation of the observed low barometer in the polar regions, or in the centre of a cyclone. Observations show that in the Antarctic region there is a permanent depression of more than 1 in. below the average height nearer the equator, and in the Arctic region a depression of about half that amount; and also that for several days frequently the barometric pressure of the central part of a cyclone is 1 or 2 in. less than that of the exterior part. Mr. Buchan, in his excellent treatise on Meteorology, attributes the low barometer in the polar regions to the effect of the vapor in the atmosphere. If the amount of vapor in the polar regions was greater than in the equatorial, this effect, so far as it would go, would be in the right direction; but just the reverse is the case; for it is well known that the amount of vapor in the warm equatorial region is much in excess of that in the cold polar regions. Attempts have also been made, without success, to account for the depression in cyclones by the effect of centrifugal force.

By whatever cause so great a difference in the barometric pressure in the different regions might be produced, it may be shown from the principles of dynamics that the equilibrium would be restored in a very short time, if there was not some constant force tending to drive the atmosphere from the polar regions towards the equator, or from the centre of the cyclone to the exterior, and to keep it in that position. Such a force may be found in the influence of the earth's rotation. In a paper by the writer in the "Mathematical Monthly" in 1860, published in Cambridge, U. S., a full abstract of which was also published in the January No. of "Silliman's Journal" for 1861, the following very important principle was demonstrated:—In whatever direction a body moves on the surface of the earth, there is a force arising from the influence of the earth's rotation, which tends to deflect the body to the right in the northern hemisphere, and to the left in the southern hemisphere. This force, which is the key to the explanation of many phenomena in connection with the winds and currents of the ocean, does not seem to be understood by meteorologists and writers on physical geography. We see it frequently stated that the drift of rivers and currents of the ocean running north or south always tends to the right in our hemisphere, and that a railroad car running north or south presses to the right; and this is the case. But the same is true, and to exactly the same amount, of a current or of a railroad car running east or west, or in any other direction.

The amount of this deflecting force, when the velocity of the body is small in comparison with that of the earth's rotation, is expressed by $2 . \frac{1}{289} \cdot \frac{v}{n} \cos. \theta\, g$; in which v is the lineal velocity of the body relatively to the earth's surface, n that of the earth's rotation at the equator, θ the angle of polar distance, and g the force of gravity. If the velocity is expressed in miles per hour, the expression in round numbers becomes $\frac{v \cos \theta}{150{,}000} g$; that is, for each mile of velocity per hour, the force is $\frac{1}{150{,}000}$ of gravity, multiplied into the cosine of the polar distance. Hence a railroad car on the parallel of 45 deg. north, running in any direction at the rate of 40 miles per hour, presses to the right with a force equal to about $\frac{1}{5{,}000}$ part of its weight.

The effect of this deflecting force upon what Mr. Stephenson calls the barometric gradient is easily estimated. Since the strata of equal pressure of the atmosphere,

so far as this force is concerned, must be perpendicular to the resultant of this force and gravity, the sine of inclination of any such stratum to the earth's surface must be $\frac{v \cos \theta}{150.000}$, and the change in barometric pressure for any given distance is equal to the weight of a column of atmosphere of a height equal to the change of level of the stratum of equal pressure and of a density equal to that at the earth's surface. The barometric gradient, then, as expressed by Mr. Stephenson, for any distance d expressed in miles is $\frac{v \cos \theta\, d}{5 \times 150.000} \times 30$ in.; putting 5 miles for the height of a homogeneous atmosphere, and 30 in. for the pressure at the earth's surface. Round numbers are used throughout, since it is only the order of the effects we wish to determine, and not their exact amount.

According to all observations, there is a steady and very strong wind blowing all around the earth in the middle and higher latitudes of the southern hemisphere, with a velocity of at least 25 or 30 miles per hour at the surface of the ocean, and this is perhaps much greater in the upper strata of the atmosphere. If at the parallel of 50 deg. we suppose the velocity of the wind v to be 30 miles per hour, the preceding expression of the barometric gradient for a distance d of 5 deg. or 350 miles, using the cosine of 40 deg., is 0.33 in. of mercury. By reference to § 113 of Mr. Buchan's Meteorology, it will be seen that the barometric gradient for that parallel is only 0.28 in. for 5 deg. of latitude, and that this is about the maximum gradient in the southern hemisphere. Hence a velocity less than 30 miles per hour at the surface of the sea, especially if we suppose that it increases in the higher regions, is sufficient to account for this maximum barometric gradient; and, according to observations, 20 or 30 miles per hour for the wind in that region is no unreasonable assumption. The eastward velocity of the wind in the different latitudes being known, and, consequently, the corresponding barometric gradients, the difference of barometric pressure between any parallel near the pole, and one towards the equator, is readily obtained by integration. As the wind near the equator is toward the west the deflecting force there is *toward* instead of *from* the pole, and hence the greatest barometric pressure is about the parallel of 30 deg., and there is a slight depression at the equator. The deflecting force and the consequent depression are small, then, on account of the small value of θ near the equator.

Since there is more land and mountain ranges in the northern than in the southern hemisphere to obstruct the eastward motion of the atmosphere, its velocity is not so great, and consequently the polar depression is much less there than in the southern hemisphere. According to Mr. Buchan the barometric depression in the Arctic regions is much greater in the northern part of both the Atlantic and Pacific oceans, than it is in the same latitudes on the continents. The explanation of this is, that the eastward velocity of the atmosphere over the oceans being much greater than it is on the continents, where it is obstructed more by friction and mountain ranges, the force driving the atmosphere from the poles toward the equator is less, and consequently the barometric pressure is less in the northern part of both oceans than it is on the continents in the same latitudes.

Upon the relative strength of the forces tending to drive the atmosphere from the poles towards the equator, depend the positions of the equatorial and the tropical calm belts. This force being strongest in the southern hemisphere on account of less resistance from friction and mountain ranges, the mean position of the equatorial calm belt is a little north of the equator, and the positions of the others a little farther north than they would otherwise be. The prime motive power also in both hemispheres being the difference of density of the atmosphere between the polar and the equatorial regions, arising from a difference of temperature and of the amount of aqueous vapor, during our summer, when this difference is less than the average in the northern hemisphere, and greater in the southern, these calm belts are forced a little north of their mean positions. Of course, just the reverse of this happens during our winter; hence we have an explanation of the annual variations of the positions of these belts.

In the case of cyclones the atmosphere at the earth's surface being forced in from

all sides towards the centre by the force arising from a difference of density of the atmosphere in the central and exterior parts, it cannot, on account of the deflecting force which has been explained, move toward the centre, without, at the same time, receiving a gyratory motion around that centre. Neither can it have a gyratory motion without also having a motion towards that centre, since in that case there would be no force to overcome the frictions of gyrations. Hence, neither the radial theory of Espy, nor the strictly gyrating theory of Reid and others, can be true, though either of them may be approximately so in special cases. But the gyratory part of the motion is not caused by the motion of the atmosphere from the north and south only toward the centre of the cyclone, as stated by Mr. Buchan and others, but equally by the different parts moving in from all sides, since, in whatever direction they move toward the centre, there is the same deflecting force, either to the right or the left, according to the hemisphere.

The motion of the atmosphere being in a spiral toward and around the centre of the cyclone, the deflecting force depending upon the earth's rotation, at right angles to the direction of motion, being resolved in the directions of the radius of gyration and tangent, the latter overcomes the friction of gyration, and the former causes a pressure from the centre, decreasing the height of the strata of equal pressure in the cyclone, and consequently diminishing the barometric pressure. The barometric gradient of a cyclone is estimated in precisely the same way as in the case of the hemispheres, using for v the lineal velocity of gyration obtained by resolving the real motion into the directions of the tangent of gyration and of the radius. It has been seen that a velocity of 30 miles per hour gives a barometric gradient of $\frac{1}{3}$ of an in. in 350 miles on the parallel of 50. A gyratory velocity therefore of 100 miles per hour would give a barometric gradient of 1 in. of mercury in about 300 miles. The velocities of gyration being known at all distances from the centre of motion, and consequently the barometric gradients, the difference of barometric pressure between the centre and the exterior, so far as it depends upon the gyratory motion, may be obtained by integration. The effect of the centrifugal force of the gyrations is generally only a very small quantity of a second order, in comparison with the other, and the effect of it is entirely insensible, except in the case of small tornadoes, when the gyrations are very rapid close around the centre.

In all the preceding estimates of the barometric gradient, it should be understood that the results belong merely to the force depending upon the earth's rotation, and to this must be added the part belonging to a difference of density of the atmosphere, which in the case of cyclones increases the gradient, but diminishes it in the case of the hemisphere. For the general motions of each hemisphere form a cyclone, with the pole as a centre ; but having the denser instead of the rarer portion of the atmosphere at that centre. Hence the motions in any vertical plane through the centre are reversed, and it becomes what has been called an anticyclone.

IMPROVEMENTS IN COAL-CUTTING.*

By Mr. W. HOOLE CHAMBERS.

From "The Mining Journal."

The number of patents that have been taken out for coal-cutting machines, and in connection with them, amounts, I believe, to considerably over 300. One great reason of failure was the employment of a motive-power which was neither economical nor beneficial. In a great number of cases the varying hardness of the holing, the changes in the nature of the roof, floor, etc., the various heights which the holing required to be in the seam of coal, the different depths of undercut required in various seams of coal in order to bring down the coal to advantage, and the necessity of having a machine which from one model could cope with all these various difficulties, have combined to prevent the success of many machines which

* Read before the Midland Institute of Mining Engineers.

had intrinsic value for one or other of these purposes, but which when applied to overcome others have signally failed. The motive-power best to be employed in coal-cutting machinery will, I believe, be acknowledged by all to be compressed air. It is easily procured ; it is safe in use ; the air is discharged into the mine fresh and pure at the working face; the average amount of air discharged by one of these machines will be 120 cubic ft. per minute.

It is not my intention in this paper to describe the machinery fully, as this has frequently been done, but briefly to notice some of the recent improvements which have brought the machine from one which had a substratum of excellence, but which by itself must necessarily have failed, to one which is a decided success. They are as follows :—1st. A solid forged frame to contain the machine, instead of a riveted one. This secures stability, and far less necessity for repairs.—2. Connecting-rods, instead of bevel gearing, for propelling the machine forwards. A much stronger and heavier machine can thus be made, and the attendant has much greater control over the machine.—3. The doubled-headed pick, having two or more cutting-blades on one shaft. This is a great advantage in coals which are liable to crush off the face, or where the roof is tender, as by going once over the face a depth of from 3 ft. 3 in. to 3 ft. 6 in. can be cut, which is quite as much as some coals will allow.—4. The curved pick, by which means the deeper the cut the less back room from the face is required in which to work the machine ; thus, when cutting to a depth of 5 ft., only 3 ft. of back-stroke is required for the machine. —5. The successful application of loose points to the pick, perhaps the greatest improvement of all. Specification of Samuel Firth, No. 943, 1869, claims a loose point by preference, having a circular taper cottered into a socket on the pick-shaft, against a cushion of india-rubber or other suitable material.

Having thus briefly noticed the improvements lately made, I beg leave to bring before your notice the following table of experiments which were made at the Tingley Collieries of the West Ardsley Coal and Iron Company, on June 8 and 9 last :—

No.	Name of Coal.	Nature of Experiment.	Distance. Yards.	Time. H. M.	Depth. Ft. In.	Av. sq. yard per hour.	Per day of 9 hours.	Nature of Holing and Remarks.
1	Middleton main...	Single pick.........	10	13 10	2 3			Usual bordway working,
1	" ...	"	10	17 34	4 0	20	180	worth 7d. to 9d. per
1	" ...	Removing machine .	..	9 0	..			hour.
2	" ...	Double-headed pick.	10	17 50	3 2	35	315	
3	" ...	Single " .	5	8 5	2 3			Very hard holing coal,
3	" ...	Removing machine	..	10 25	..	13	117	working endway with-
3	" .	Single pick.........	5	9 10	4 0			out any weight on.
4	" ...	Double-headed pick.	5	25 0	3 3	13	117	"
5	" ...	Single " .	5	16 0	5 4	12	108	"
5	" ...	No. 3 ex...........	..	27 40	..			
6	" ...	Single pick......	5	17 0	5 0	13	117	"
6	" ...	No. 4 ex...........	..	25 0	..			
7	Little coal	Double-headed pick.	10	40 0	..	15	135	Medium between 1 and 3, standing some time, and much dirt fell.
8	Stone coal........	" ..	5	23 0	3 0	13	117	Very hard stone and dirt intermixed.
9	" ...	" ..	5	37 50	3 0	8	72	"

In experiment No. 1, which was in the Middleton Main, or Silkstone coal, the bank was working broadway ; it was 61 yards long, and about 1 mile from the pit bottom. The holing is done in the Baring coal in this seam, which is 1 ft. 3 in. from the floor. Experiments 3, 4, 5, and 6 are in the Middleton, or Silkstone coal, working endway ; the bank having only just been opened, the coal is very hard. No. 5 experiment is over the same ground as Nos. 3, and No. 6 as No. 4; the steadiness of the machine on the road, and the beautiful regularity of the stroke in these two experiments were delightful to see.

In the Little coal the holing is done

close to the floor, the bank is working bordway of the coal, and a 3 ft. fall is as much as this coal will allow.

In the Stone coal the holing is done in the stone and dirt between two seams of Cannel coal ; this was by far the hardest we encountered. Some idea may be gathered of the hardness, when I state that on an average it required 19 blows of the pick in the same spot before the full depth was reached, and sometimes as many as 21 and 22. It is far too hard to be done by hand-labor, but is the best part in the seam in which to hole.

We have before us 5 machines working in 3 different seams of coal, in one of which we have two species of work, all of which machines are doing well. The hardness of holing varies from comparatively easy holing, as in the Middleton or Silkstone coal, working boardway, to holing too hard to be done by hand, as in the Stone coal. This machine will, therefore, adapt itself to any hardness of holing ; it can also hole at any height in the seam of coal which is requisite, by means of a false-bottom.

In the Middleton coal the holing is 1 ft. 3 in. from the floor, in the Stone coal about 5 in., and in the Little coal on the floor, and you have equal stability in either case. It can work in any seam of coal where 2 ft. of height can be secured, and only requires 3 ft. of room from the face in which to work ; this is most remarkable where the depth of holing was 5 ft. 4 in., and only 3 ft. of room from the face required.

I would here briefly direct your attention to the reasons why, in many cases, where formerly powder was required to bring down the coal, by machine holing none is required. First, the weight of coal is left on by machine holing at the face, whereas by hand holing 9 in. at least is taken away at this point. Not only is this the case, but the line of gravity of the block holed is by machine holing brought much further forwards in the block of coal holed. By these two forces combined, if we take a block of coal 100 yards long and 3 ft. high, I reckon the power of separation will be increased by at least 40 tons, thus giving us an immense increase in the natural tendency of the coal holed to separate itself from the solid coal.

Before quitting the subject of the advantages of holing by machinery, I would point out those which are gained by the workmen. In the first place, the hardest portion of their work is taken in hand and successfully done for them ; but what I regard as more important than the above is the immunity from accident from falls of coal which is offered. In the position which a man occupies whilst working the machine he is brought out of the groove which in hand holing he has to work under, and where he has neither inclination nor opportunity for examining the changes constantly taking place along the face of the coal. He can see in a moment any indication of the coal giving way, and is in such a position that he can easily get out of the way in such a case. The numerous accidents which occur to men whilst holing, from falls of coal, stamps this as a great advantage. The average length of life among our colliers is very short ; no doubt this is partially due to the atmosphere they breathe being so thickly impregnated with coal-dust, and partially to cramped postures which have to be assumed in holing, sometimes for hours together. Immunity from the last is, as will be easily seen, insured by the machine under notice. The exhaust air is also so arranged that it blows the dust created in holing, away from the man who works the machine, leaving him in an atmosphere comparatively pure. You will see, then, that the advantage is not all on the side of the master, but is shared by those whom it is always our duty to consider in weighing the gains and losses of any important alteration like the present in the system and mode of working our coal ; I mean the working colliers.

I have endeavored to lay before you in the foregoing paper, results which have come under my personal observation. I would not be understood to say that this is the best machine in existence, or that can possibly be produced ; but I can say without fear of contradiction that every part of the machine is well and carefully considered, that strength is applied just where it is wanted, that the results obtained in the length of holing are better than I anticipated, and quite sufficient to prove it a decided success, and that no other machine has yet come under my notice which has succeeded as well as the above. In conclusion, I call upon you to give this subject your earnest consideration, for I hold that all these experiments, which are of so much vital importance to the coal

trade in general, demand our encouragement; and that where we find such patient study, such determination to overcome all difficulties, and such unremitting exertions as must have characterized the patentees of the machine under notice to have brought it from what it once was to its present state of perfection, we are called upon, having the interests of mining at heart, to give every aid in our power to the successful application of that which we cannot but feel is absolutely necessary to the full and cheap development of our coal-fields.

AERIAL FLIGHT, AS DEPENDENT ON MAN'S MUSCULAR EXERTION.*

By A. ALEXANDER, C. E.

From "The Mechanics' Magazine."

Very few of the methods which have been proposed, from time to time, for accomplishing aërial navigation have been submitted to anything resembling even a remote approach to practical tests; and hence, in the mind of each projector, there is a tendency to assume for his scheme a measure of success even in cases where this idea would be effectually dispelled by an actual trial.

If we put the balloon out of consideration, the different proposals made from time to time may be divided into two distinct classes—viz. (1), those in which the power necessary for flight is supplied by an engine actuated by steam, gas, or other similar agency; and (2), those in which the power is to proceed from the muscular exertion only of the flyer. In the first class it is assumed that man's muscular power will be insufficient to support flight beyond more than, at the best, a very short distance; and, in the latter class of plans, this power is obviously considered by those who approve them as adequate for flight of such duration as to be practically useful.

While the writer of these remarks must rank himself decidedly with the supporters of the former class, yet he is fully aware of the importance of avoiding any dogmatic views in a matter of which we as yet know so little; and he has, therefore, availed himself of some opportunities to examine various schemes for flight by muscular power, with the view of ascertaining their merits or defects.

Now, the detection and precise statement of any weak point in the reasoning by which a peculiarity of construction is defended, certainly comes next in importance to the suggestion of methods for actually accomplishing the end in view. By thus, as it were, clearing the ground, our time and means are not taken up, as they might otherwise be, in labors which will yield no satisfactory result. It is, therefore, thought to be desirable to point out to the members of the Society what is considered to be a fallacious mode of considering the action of certain apparatus for achieving flight.

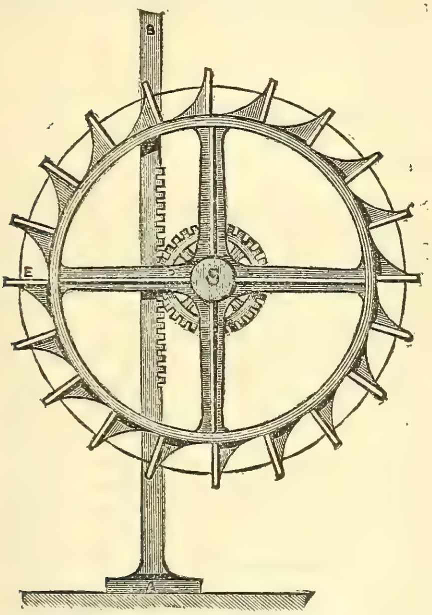
The writer has been led to this by his examination, at the request of our secretary (Mr. F. W. Brearey), of the plan and arguments brought forward by Mr. Craddock (whose ingenuity and valuable suggestions in other fields of mechanical inquiry seem often to have been appropriated without acknowledgment) for accomplishing flight by muscular exertion simply. Mr. Craddock had patented his plans in 1867 (No. 1,982), but the drawings more recently prepared showed a considerable improvement on the patented design.

It must be noted, however, that these remarks do not refer to any special apparatus, but exclusively to a special argument or point of view, by and from which such apparatus are justified, and their practical utility asserted. The reasoning by which the sufficiency of such apparatus was supported is as follows:

Suppose an upright metal rack A B resting on the ground at A, and gearing into it is a pinion C D, which is on the same centre or spindle as the wheel C E. This wheel is provided with steps round its circumference. The pinion C D being supposed to be kept in its place, and prevented from falling back out of gear by suitable guides, it is obvious that, were a man to place himself on the steps of the

* Read at the last meeting of the Aeronautical Society.

wheel, he would by its rotation elevate himself to any desired height. The apparatus, in fact, constitutes an ascending treadmill, and there can be no doubt that, with a break, provided upon the upright guides to regulate the speed, a man might mount in this way without difficulty.



"Now, here," say the advocates of the muscular system, "the man's force is, *with a suitable mechanism*, perfectly competent to raise himself to any given height, and that the air may take the place of the rack in this arrangement, it is only necessary that the *leverage be adjusted* to that end. It is a mere question of leverage; for we know that an extended surface, if moved with sufficient velocity, will sustain a reaction equivalent to the weight of a man. Let the leverage then be adjusted, but in the inverse direction, so that this velocity may be obtained from the man's motion, and he must rise just as he does when supported on the metallic staircase."

This mode of considering the matter is plausible, but it involves, I think, the fallacy of assuming the very point which is in doubt. It appears so evident that if a surface or surfaces be moved with sufficient rapidity, they will counterpoise the weight to be raised; and then, this being allowed, that a man will be able to raise himself on the rack-like support thus afforded, that one is apt to consider the rack as a *fait accompli*, in which case we can hardly avoid the conclusion that by its aid we may ascend to any desired altitude. But the fallacy here consists in assuming at all, without proof, the existence of the aërial rack, or, rather, in assuming that a man's force is competent so to move surfaces that an effective and effectual reaction may be obtained from them. With the form of illustration above explained, the mind is apt to dwell on the fact that the muscular power is thus shown to be sufficient, by appropriate mechanism, to raise the body, while it assumes that, as the intervention of mechanism involves no loss of power apart from friction, the conversion of the slow into the quicker motion required is a mere matter of mechanical detail. But it must not be forgotten that the muscular power has to effect two objects—1st, to produce such motion in surfaces sufficiently extended, that the weight of the body shall be counterbalanced; and secondly, to elevate the weight of the body upon the aërial rack thus produced. The first part of the business is precisely that which it is assumed has been done by drawing the rack on paper; but it is that which in fact constitutes the sole difficulty, and the possibility of which is denied by many.

Supposing it to be effected, we can easily see that the *ascent* of the rack, or the actual elevation, would require the most trifling addition to the force alread supplied; for if a certain mass be in perfect equilibrium in space, a very small force will, if sufficient time be given, generate any velocity required, the resistance of the atmosphere being excluded. Taking this resistance into account, it would still be true that a very small force, continuously applied, would suffice to generate a high terminal velocity. Returning to the rack illustration, if the radius C E of the path on which the man travels were to coincide with the radius C D of the toothed wheel, then evidently (apart from the weight of the apparatus) the man would be in perfect equilibrium; but a very small increase of the radius C E would suffice to produce an upward movement and relatively downward movement at E of the revolving platform, so great that a man's speed would be unable to keep up with it. No just inference can, therefore, be drawn from reasoning founded upon the ease with which muscular exertion would enable us

to rise by means of such a revolving platform as that which has been described; for, to assume the possibility of any reaction from the air due to the muscular force expended, and akin to that afforded by this platform, is to assume the very point at issue. The writer, while far from wishing to discourage inquiry on the part of those who may think otherwise, has long been of opinion that man's muscular exertion will be found in all cases quite inadequate to maintain any such reaction for more than the shortest space of time, and that to accomplish aërial navigation in a comprehensive sense we must obtain a proportion of power in relation to weight considerably greater than we at present possess.

M. JANSSEN'S AERIAL EXPEDITION.

From "Engineering."

M. Janssen has furnished to the Academy a report of the aërial voyage which he undertook on the 2d of December, 1870, to join the expedition to Algeria for observing the eclipse of the sun on the 22d of December. The learned astronomer, wishing to pass the lines of the Prussians without soliciting permission of the enemy, decided to take his route through the air. In the absence of any experienced aëronauts, he himself undertook the command of the Volta, and quitted Paris on the 2d of December, at 6 A. M., from the Orleans Station, accompanied by a marine named Chapelain. The Volta had 2,000 cube metres capacity, and, although hurriedly made, offered sufficient guarantees of stability and strength. It carried an equatorial parachute formed of a band of stuff 3 ft. wide, running round the centre of the balloon, fixed on the upper side, and bound on the lower side by cords to the lower part of the balloon. Inflated with ordinary gas, the Volta had a rising force of 3,080 lbs., divided thus:

Weight of the balloon complete ..	1,144 lbs.
Instruments......................	352 "
Two aëronauts....................	330 "
Ballast	1,254 "
	3,080 lbs.

The instruments were reduced to their essential parts, and were to be completed at some large town on the route. These delicate pieces of mechanism were carefully packed in boxes, arranged so as to resist violent shocks. On departure, the astronomer judged that he was taking a southerly course. Ballast was thrown out, so that the line of investment might be passed at a minimum height of 3,000 ft. At 7.15, the barometer stood at $25\frac{7}{16}$ in., and the thermometer at 30.20 deg. Fahr., and the direction was more decided towards the west. The balloon crossed the Eure to the north of Chartres. At 7.35 the sun rose, the air cooled rapidly, and the thermometer fell to 19.40 deg. The balloon fell rapidly; ballast was thrown out. M. Janssen explains the apparent contradiction of the falling temperature and the rising sun by the fact, that the first rays of heat dispersed the atmospheric vapors, and thus increased the radiation from the balloon. Up to 8 o'clock, the effect of the solar radiation made itself felt more and more; the balloon rose, the thermometer fell. To ascertain the direction, M. Janssen made use of one of the points of the anchor suspended to the car. This point traced on the ground a line easy to follow. It was enough to align one side of the compass box with this direction, to know the angle made by the route with the magnetic meridian. At 8.17, the direction was east, quarter south; the temperature was slightly raised, the weather magnificent. It was perfectly easy to make all observations, although the speed was 50 miles an hour. At 8.48 the balloon passed to the north of Mans. The town lay stretched out below so clearly visible in all its details, that it would have been possible to take of it photographic pictures. At 9.45, the balloon attained an elevation of 6,000 ft.; the barometer marked only 23 in. This elevation was due to the heating of the gas. At 10.40 it descended, the exterior air beginning to heat faster than the gas in the balloon. The barometer indicated 33.80 deg. The travellers passed over Château Gontier, whence a confused noise of acclamations was perfectly audible.

At 11.15, the astronomer saw that they

neared the sea; it was necessary to descend without losing an instant. The valve was opened, and the barometer rose from $23\frac{5}{16}$ to $27\frac{9}{16}$ in.; it was a vertical fall of 4,500 ft. The valve was closed, and ballast was cast out, to reduce the velocity of the descent. The fall thus checked, the balloon rose a little, and a height of 1,200 or 1,500 ft. was maintained. Again, the descent was accomplished to within 600 ft. There remained the final fall, always difficult and dangerous, but which, in this instance, promised to be accomplished under favorable conditions. Opening the valve, M. Janssen caused the balloon to descend, and a sack of ballast being thrown out, a height of 150 ft. was preserved. The guide rope was then cast over—a long, heavy cord of 600 ft.—which, by its trailing along the ground, served as a brake. As soon as this rope struck the ground, it produced an ascensional undulation, followed by a soft and very oblique descent. Suddenly they neared a church steeple, which they cleared with a bound by throwing out a bag of ballast. The balloon then followed across land intersected with hedges. The marine threw the anchor, and opened the valve, but the anchor broke, and, after an instant, the balloon gathered speed, breaking through hedges and trees. At last the speed decreased, thanks to the friction of the guide rope, which was seized by the peasants, and the adventurous travellers landed safely with all their instruments near St. Nazaire.

M. Janssen continued his scientific journey without further trouble. The voyage of the Volta proves the possibility of transporting, by the aërial route, heavy and delicate instruments. It is, moreover, especially interesting from the point of view of the physical atmospheric question. The study of this question will prove of much value in aërostatic observations.

STEVENS INSTITUTE OF TECHNOLOGY.

In number 33 of our current volume, we gave an engraving representing the exterior of the new School of Science and of Mechanical Engineering, now open at Hoboken, N. J.

The Stevens of Hoboken have been known for three-quarters of a century past, as active, intelligent and successful engineers.

Col. John Stevens began about 80 years ago to experiment with a view to the introduction of steam in the propulsion of vessels, and showed his remarkable genius by, at that early day, setting afloat a twin screw steamer with a tubular boiler, which he ran on the North River in 1804. The machinery of this boat is carefully preserved, and is given a prominent position in the model-room of the Stevens Institute of Technology.

Another boat succeeded, the Phenix, which came out simultaneously with Robert Fulton's boat, the Clermont. Still later he turned his attention to the use of steam on land, and, even before Robert Stephenson had commenced his now famous work, Col. Stevens planned and described almost precisely a prototype of the modern locomotive, and, predicting with wonderfully accurate prophecy, its great work and the limits of its powers, applied himself with characteristic energy to secure its introduction nearly 20 years before its success became a generally known fact.

Dying in 1838, at the advanced age of 89, Col. John Stevens left behind him sons well worthy of such a sire, and the inventions and the engineering of Robert L. Stevens are as well known to engineers as were the achievements of his father. He introduced hollow water lines in the Phenix and feathering paddle-wheels in 1809, used steam expansively on the Philadelphia in 1815, and put the now universally used skeleton beam on the Hoboken in 1822. He strengthened the North America with a "hog frame" in 1827, adopted return tubular boilers in 1832, steam packets pistons in 1840, the Stevens Cut-off, designed by himself and a relative, F. B. Stevens, in 1841, anthracite in locomotives in 1848, and many other equally valuable and remarkable advances in mechanical engineering were due to R. L. Stevens.

The celebrated "Stevens Iron-Clad" was one of the most remarkable of this great engineer's projects, and, with its great size and fine proportions, its iron

hull, its athwart ship bulkheads, its double bottom, its independent twin screws, and its return tube boilers, it stands to-day, a most formidable war vessel, and an appropriate monument to its talented designer.

Another of the sons of Col. Stevens, Mr. Edwin A. Stevens, was also a man of great constructive talent; and in carrying out the designs of his deceased brother, as well as in independent labors, he exhibited the same "Stevens ingenuity," energy, and intelligence.

He, however, has erected even a nobler memorial than did his brothers, or even his father. His last and posthumous work is a fitting monument to himself and to the family.

By a provision of his will, a square in the city of Hoboken was set apart, and the sum of $150,000 was appropriated to put up a building to be devoted to educational purposes, and a further sum of a half million dollars was to be invested as a permanent endowment with the income from which the regular expenses of the school were to be met.

The trustees, Mr. W. W. Shippen, Rev. S. B. Dod, and the widow, Mrs. E. A. Stevens, have bravely carried out the noble plan sketched for them.

The institution with peculiar appropriateness, as well in view of the bent of its founder's genius, as in compliance with the now fully recognized and earnestly proclaimed needs of the time, has been planned as a School of Mechanical Engineering and of Applied Science, and its courses of instruction—while omitting no part of the usual scientific courses of our colleges, and, indeed in its physical laboratory going far in advance of the usual college course—are all so directed that the student will find in all of them essential aid in, and preparation for, his professional course.

Beginning our description with the lower portion of the building, we find in the basement at the western end, a large room containing two large boilers for heating the building, and supplying steam to drive the steam engine. It also contains the furnaces required in the metallurgical department of the chemist's technical course. At the opposite end of the building we find a pair of steam engines which drive the machinery of the machine shop. The machinery and tools are carefully selected, and of the best materials and workmanship. A pattern maker's and a machinist's bench are placed here also, and all of the smaller wood and iron working tools.

Partitioned off from the shop by a neat metal screen, is a space containing a furnace for supplying oxygen, and also tanks for retaining both oxygen and hydrogen, under the pressure requisite for the successful use of the oxyhydrogen light and blow-pipe. From these tanks pipes lead to all the lecture-room tables.

The basement also contains several store-rooms, a glass grinding-room, and a battery-room, where the large Voltaic batteries are kept, and under the west wing are the assay-room, and the apartments of the Janitor.

Passing up stairs and turning into the west wing, we find its three floors entirely devoted to the Department of Chemistry.

On the lower floor is the working laboratory, where analyses of ores and other minerals and materials used in the arts may be tested and valued. On the second floor is the lecture-room, neatly fitted up, and supplied with every convenience that ingenuity could suggest and art could furnish, and, on the upper floor, are a mineralogical cabinet, Professor Leeds' private room, and a laboratory in which to carry on his own independent researches.

Returning to the main building, first floor, we enter at the western end, the library and model-room. Here are a considerable number of book and model cases, all of which contain much that is of interest.

The library is intended to be purely technical, and to be very complete in works relating to mechanical engineering. The models placed here are generally those of unusually popular interest, and, when the orders given abroad are filled, this room will be a museum of great attractions.

Here is the old engine built by James Watt, for Col. John Stevens, with its tubular boiler and the twin screws just as they were designed by the last named remarkable man, and as he used them sixty-seven years ago. Here are models of the great "Stevens Battery," the first effective design of iron-clad ever proposed, and constructed; here are steam engines, pumps, regulators and water wheels, and many kinds of machinery.

Here is the great "Inductorium," capable of sending its lightning-like spark 21 in. through the air, and *through glass 3 in. thick,* and pieces of glass thus pierced lie on the shelf above it.

Here is a Scott "Phonautograph," which reduces audible sound to a legible character, and with it large numbers of interesting and curious acoustic apparatus; here are probably the largest selenite objects in the world, displaying their wonderful changes of color under polarized light; here are Professor Mayer's neatly fixed "Magnetic Spectra," displaying the lines of magnetic force as they actually exhibit themselves over the magnet.

Here is also a little brass model and lithograph, exhibiting John P. Taylor's armored torpedo boat of 1845, probably the first armored torpedo boat ever designed.

But, interesting as they are, we cannot attempt to fully describe these collections, for much of equal interest is found elsewhere.

At the eastern end of the building, and on this floor, is the Physical Laboratory, which is placed under the care of Professor Mayer. The room is as large and as finely lighted as the library. Here we find ten alcoves, separated from each other by apparatus cases, each being devoted to a single class of work. One alcove is devoted to electrical measurements, and its case contains a set of splendid apparatus made by Elliott, of London; another is devoted to optical researches ; still another to the investigation of the laws of heat, and another to molecular physics; and each is supplied with a complete set of the needed apparatus.

Here is mounted the largest electromagnet in the world, weighing nearly a ton, and capable of supporting many tons of iron ; here we find apparatus so delicate as to be capable of indicating the changes of dimension produced by magnetizing an iron rod, and even of measuring their amount, by the movement of a spot of light reflected upon the wall. Here are delicate thermometers, fine metric and other measures of space, barometers, spectroscopes, and all those other curious and wonderful pieces of apparatus with which our wonder-exciting friends, the physicists, are astonishing us daily.

And here the student is expected to work until he has become as familiar with the apparatus for determining the physical properties of the useful metals, familiar objects, and elements and forces, as he has been made, in the room below, with the tools of wood and of metal workers.

We have time to take a mere glance here, and we pass up to the second floor.

At the east end, we find a pleasant, well-lighted lecture-room, stocked with apparatus, and occupied by President Morton in the prosecution of his own scientific labors, and intended, also, to be used as his lecture-room in the subject of *theoretic mechanics.* Large drawings of a section of the Giffard injector, and of other machinery and apparatus, hanging on the wall, indicate that he proposes to adopt unreservedly the "technical method," illustrating his theoretic teachings by technical problems and exercises.

Here he devises the brilliant experiments that, with the more brilliant lectures that they illustrate, have delighted so many intelligent audiences.

The next room is the lecture-room of Prof. Mayer, and is devoted to instruction in physics.

The lecture table is completely fitted up like the others, with pneumatic trough, illuminating and oxygen and hydrogen gas-pipes leading from the tanks in the basement ; fixed wires from the battery room, and a "vacuum pipe" leading to a plate fixed upon the table from the Bunsen air-pump, so that a vacuum may be *turned on,* like the gas, by turning a cock. Professor Mayer's study is next door (No. 15). The Professor has evidently a mechanical bent, as we find in his room a neat Stewart lathe and a work-bench ; and, in his cases, many samples of his workmanship, in the form of ingeniously contrived apparatus used in his magnetic and other investigations in physics.

In Room 14, directly over the main entrance, is the optical cabinet, which contains the celebrated Bancker collection from Philadelphia—a most interesting as well as large collection. When this is supplemented by the additional apparatus ordered at home and abroad, it will be, by far, the most complete outfit of optical apparatus possessed by any institution in the world.

Room 13 is the study of Professor Thurston, the head of the Department of Mechanical Engineering. The fine photographs of locomotives and other pictures

of machinery, ships and iron-clads hanging on the walls, and the collection of models and drawings, and the mechanical curiosities lying about, indicate that our mechanics, manufacturers, and inventors already see, that by aiding the Professor in his work they still further assist themselves.

Room 12 is Professor Thurston's lecture-room, a fine, large and lofty room, probably 35 ft. square. Along one side extends a great case (for models) of black walnut, and of neat design, which is rapidly filling with models of various kinds of machinery, made both at home and abroad.

Among the models already received, is a beautiful pair of oscillating steam engines, with feathering paddle-wheels, just as they were fitted in so many blockade runners during the war, complete in every detail, and beautiful in finish and workmanship.

Another is a model stationary engine, of $1\frac{1}{2}$ in. diameter of cylinder, and $4\frac{1}{2}$ in. stroke, made by the Professor when a schoolboy, with boiler and Greene's "drop cut-off" complete, even to the details of its little "fly-ball regulator." It is hoped that our steam engine builders will make this collection of engine models very complete.

Here is a beautifully finished Giffard injector, with all its appurtenances, cut open to show its interior construction—a contribution from Sellers & Co., of Philadelphia; here is a silver-plated model of Mr. John F. Ward's spherical water-pipe joint; here are steam engine indicators, gauges, rail fish joints, a model brick-making machine, and still room for the large collection of models of simple machines and elements of machines ordered from Darmstadt, Frankfurt, Paris, and in our own country.

At the side of the room, opposite the model cases, is a long table, fitted with over 30 drawers, for working drawings of machinery. Some very valuable contributions have already been received, and others are coming from our enterprising and liberal manufacturers. One drawer contains over 60 drawings—a complete set—of a marine engine of 1,000-horse power, from Mr. Geo. B. Whiting, chief draughtsman of the Naval Engineer Department; and another contains a set of tracings of an inclined engine of 60-inch cylinder and 10-feet stroke, also from the private collection of the same gentleman. Other drawers contain drawings from other generous contributors, and sets purchased in Europe; and still other drawers are depositories for the private collections of the Professor.

Additions are frequently being received, and others promised by friends of the good cause.

We ought not to forget to mention the numerous drawings which exhibit the progress of the Stevens iron-clad, from its inception to the present time. On the wall, among other pictures, is to be noticed a drawing of a Babcock and Wilcox boiler, which is a very remarkable specimen of fine work with the drawing instruments.

Many rooms remain to be described, but our space will not admit, even were they of equal interest to our readers, a detailed description of the mathematical department, the drawing rooms, the photographic and photometric rooms, and the workshop of the instrument makers to the Institute. The Institute and the latter gentlemen—Messrs. Hawkins and Wale—are equally fortunate in effecting an arrangement such as that which, a century ago, at the University of Glasgow, resulted in the grand series of inventions of James Watt, the mathematical instrument maker to that college.

In a succeeding number, we will endeavor to find space to describe briefly the proposed course of instruction at the Stevens Institute of Technology.

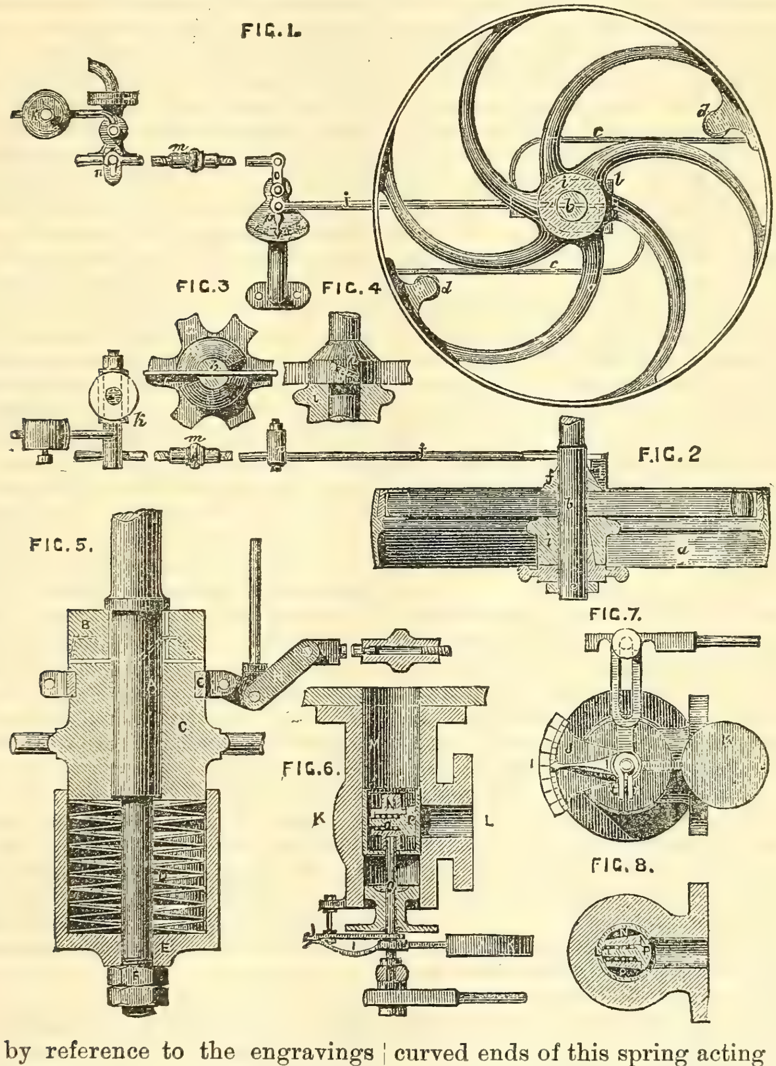
The new line of tramway laid down from Brixton to Kennington was opened lately for public traffic. Large and convenient carriages on low wheels continue to run over the metals, and conveyed good loads of passengers each journey. The vehicles are capable of carrying 46 persons, one-half inside, and the other half on the roof of the carriage. The fare is two pence either way. The omnibus fares have been reduced to the same figure. The tramway to Clapham is now in course of construction, and will be united with the Brixton line at Kennington, and then continued to Westminster.

Oudemons has succeeded in making an alloy of zinc and iron. The new metal, which contains 4.6 per cent. of iron, is remarkable for its whiteness and tenacity.

GAUTREAU'S DYNAMETRICAL GOVERNOR.

From "Engineering."

We here illustrate an arrangement of "dynametrical governor" designed, and patented in this country, by M. Jacques Théophile Gautreau, of Paris, and which is intended for use either as a dynamometer, or as a governor for regulating the supply of steam to an engine according to the amount of work that engine is actually performing. The construction of the apparatus can be best ex-



plained by reference to the engravings which we annex. In the arrangement shown in Figs. 1, 2, and 3, the driving wheel, *a*, is loose on the shaft, *b*, and rotatory motion is transmitted to it by means of a spring, *c*, which is formed of a blade of steel, and passes through the shaft, *b*, to which it is thus firmly secured, the curved ends of this spring acting on rollers, *d*, which are carried in bearings, *e*, cast in one with the pulley, *a*. The angular displacement which may thus be produced between the wheel, *a*, and the shaft, *b*, is transmitted to the throttle valve by a boss, *f*, fitted so as to move with but little friction along the shaft, *b*,

and recessed in order to admit of the spring, *c*, passing through it, by which means it is caused to turn with the shaft, *a*, whilst at the same time it is free to move longitudinally along it. The boss, *f*, has formed on its periphery a heliccidal groove, *g*, in which a pin, *h*, works, which pin is carried by a projection cast in one with the boss, *i*, of the pulley, *a*. By this means any displacement of the pulley in relation to the boss, *f*, produces a corresponding linear displacement of the latter in the direction of the centre of the shaft, *b*. This linear displacement is in its turn transmitted to the rod, *j*, which actuates the steam inlet cock, *k*; for this purpose the boss, *f*, is provided with a conical surface on which an inclined abutting piece, *l*, slides, which is maintained between the bifurcated extremities of the rod, *j*.

In order to facilitate the regulating of the engine the rod, *j*, is provided with a screwed socket, *m*, which admits of the length of the rod being varied, and the original position of the cock or sector, *k*, being determined, the plug, *n*, of the cock is also furnished with a slot in which a button on the end of the rod, *j*, is capable of moving, by which means the opening of the cock for a given amount of linear displacement of the rod, *j*, may be varied at will.

In order to utilize the apparatus as a dynamometer, it is simply necessary to interpose on the rod, *j*, a lever, *o*, provided with a hand or pointer, *p*, to move over a divided dial or quadrant, *q*. By this means the amount of motive power transmitted by the engine may at each instant be ascertained, and the relative proportions of the two arms of the lever, *o*, co-operate to determine the admission of steam to the engine in proportion to the tractive strains which the driving belt has to overcome.

Figs. 4, 5, 6, and 7 illustrate another type of governor which differs from that herein before described, in that the blade springs are replaced by disc springs, and that the rectilinear displacement which has to act on the valves is obtained on the driving wheel itself. This arrangement, therefore, is not applicable to where gearing is the medium used for transmitting power, but simply when a belt and pulleys are employed. B is a collar which is fast on the shaft, A, and is provided with a series of teeth or inclined planes corresponding to similar inclined planes cut on the boss, C, of the driving wheel; the boss, C, which is loose on the shaft, A, is maintained against the collar, B, by a series of disc springs, D, disposed around the shaft, and enclosed in a box, E, the position of which is adjusted by means of the nuts, F, which determine the degree of tightness of the springs, D. The effect of this arrangement is that when any variation takes place in the strain transmitted by the belt, the springs, D, bend, and the oblique teeth of the boss, C, engage more or less with those on the collar, B; the position of the driving wheel on its shaft is thus changed, and this variation is transmitted to the valves by means of the collar, G, and the cranked arm, H. In this type of governor, as in the preceding one, an indicating hand or pointer, I, moving over a dial or quadrant, J, is employed for the purpose of indicating at each instant the amount of motive power transmitted by the engine, and a counterweight, K, is provided, which has a constant tendency to bring back the driving wheel to the required position when a change in the deflection of the springs, D, takes place.

The description of valve which it is proposed to employ with this system of governor, is shown in Figs. 5, 6, and 7. It is composed of a brass box, L, fixed in the interior of the steam pipe, M, in which moves a piece, N, actuated by the rod, O, which carries the indicating hand or pointer, I, and the counterweight, K, and actuates a cylindrical closer, P, intended to more or less cover the aperture through which the steam enters the slide valves. In order to compensate for the wear which may take place during the working, the cylindrical closer, P, is constantly maiatained against the inlet aperture by means of a helical spring, Q, which is disposed in the interior of the piece, N.

The cultivation of the tea plant promises to become a source of wealth to California. The tea plants, which already number 300,000, are doing well. One of the clearest burning oils—China oil—is extracted from the tea nut, and enchances the profits of tea culture. The Chinese and Japanese immigrants supply suitable labor for the new plantations.

CHINESE AND JAPANESE ART, AND ITS IMPORTANCE FOR MODERN ART-INDUSTRY.

By JACOB FALKE.

From "The Workshop."

Eastern Asiatic art was formerly diligently sought after and highly prized in Europe, and in the *Rococo* age, especially in the first half of the 18th century, it exercised great influence in our decoration, our Art-Industry, and our taste, which it helped to metamorphose, and to which it gave a character of bizarrerie peculiar to the *Rococo*. Numbers of amateurs then formed collections, such as the Japanese Museum in Dresden; the palaces of the wealthy had their Chinese cabinets, the dwellings even of private citizens boasted many Chinese ornaments; in a word, China and Japan were the fashion.

At the present time it is far otherwise. In comparison with the general estimation they enjoyed in the former century, the art productions of these countries are fallen into open discredit. Art-History, which in the time of the *Rococo* had no existence, takes no notice of them; private houses know them no more, or at most only in Holland; amateurs have become rare, though the collectors who still affect them are by no means of the most contemptible class, and some even rank among the most discriminating friends of Art.

It must be confessed too, if we wish to be honest, that this discredit is apparently not without good reason, and must have been a necessary consequence of the progress of taste. In the first place, Chinese and Japanese Art deteriorated essentially during the last century both in taste and workmanship, so that the ordinary new patterns which came to us, and indeed still come to us from those countries, seldom deserve any special consideration. In the next place, the forms of their vessels and other articles, no less than the ornaments, are most extravagantly bizarre in their design, so that a taste which had been formed by the observation of antique works of Art, or those of the Renaissance, and which was not able to overlook those deficiencies and to appraise the other sides of artistic and decorative beauty, would of necessity be repelled from them. And this must have been the case at the end of the former and the beginning of the present century, when the revival of the Antique during the French Revolution and the Empire suppressed all other forms of Art, and discarded all other taste.

Yet, nevertheless, this Eastern Asiatic Art, when examined with that critical eye which can discern the wheat from the chaff, and which does not look to it for that which it does not possess, but only regards its peculiar beauties and excellencies—nevertheless, I say, it offers sufficient artistic peculiarities to merit, for their sake, the consideration of the friends of Art of the present day, and to be a useful adjunct to any museum or institution devoted to that practical æsthetic object, the elevation of taste and of modern Art-Industry. It is from this point of view that we would proceed in the present article, to glance at Chinese and Japanese Art, its peculiarities, its beauties, and its excellences.

It is commonly supposed that those qualities which are at all worthy of consideration for modern Art-Industry consist solely in special workmanship, as for example, the excellence, solidity and lustre of the lacquer work and polish, to which our artists cannot in any degree approach. But so exclusive an opinion is assuredly a mistake; the artistic work of the Chinese and Japanese—by which we intend the productions of Art-Industry, and not their pictures or purely plastic works—have positive æsthetic peculiarities which demand recognition. We must only take care not to look upon the object as a faultless piece of work according to æsthetic principles, as pure in form, design and ornamentation; we must consider that this or that determinate creation, this or that determinate figure, was partly owing to their histories and tradition, partly to their civil and religious laws, under pressure of which the artist was obliged to bend. We must conceive of these works from the point of view of decoration, we must try them by the effect which they produce as a whole, and by the way in which they harmonize with other works of Art. We may then go farther, and shall find much that is charming and attractive in the details and peculiar structure of their creations, if

only we do not expect these advantages in the very first object that meets our eye.

Considered under this decorative point of view, those artistic productions of Eastern Asia, even the most modern and the most common, never appear without harmony in their coloristic effect, never glaring and hard in their tints, a defect which till of late, and even now is so general in modern Art-Industry. The newer Chinese works may often be liable to the reproach of paleness and feebleness of color, which, however, is not always a defect; but the composition is always correct, and the effect pleasant to the eye. This is a quality which deserves to be well considered by the Art-Industry of the present day, and which in its time the *Rococo* well understood how to turn to advantage. But if we separate the really good from the common and poor, which the Chinese, as a rule, sent to us as good enough for "the Barbarians," and if we fix our attention especially on the more ancient objects of Art, to whatever branch they may belong, we shall be obliged to acknowledge their positive excellences. Instead of that mere harmony which appears frequently to be a purely negative excellence, we shall come upon effects of color which are most admirable, full of glow and depth, quiet and sober, yet still rich and elegant, which would do honor to any time and any style of Art, and which are highly to be recommended for study and imitation. We shall find also a quantity of originally shaped vessels, which just as they are, or perhaps with only and slight alterations, would be suitable for our modern use and even satisfy a delicate perception of form; and lastly, even in the ornamentation, in the conventionalizing of the flowers, for example, as found in the more ancient works, we shall discover motives which may be useful for decorators of the present day. We put on one side the workmanship, which is partly lost even to the Chinese themselves, but which might be most advantageously revived.

In order to commence at once with the greatest excellence of the Chinese productions, we had especially in view, in intimating the above-mentioned effects of color, their older copper vessels with cloisonné enamel, which are now to be seen in many modern collections, and particularly in private possession. They are altogether absent from more ancient collections, because, being most highly esteemed by the Chinese themselves, they were seldom exported from their own country, but were almost always carefully hoarded in the royal palaces of Pekin, and it is only since the taking of that city by the French and English, and the consequent pillage of the palaces, that they have come to us in any quantity, so that they continue to maintain a high value.

The Chinese enamel has taken pretty nearly the same development which the history of this branch of Art shows to have taken place among ourselves, at least in its three principal forms. These are, 1. The cloisonné enamel; the enamel that is enclosed in cells or compartments by gilt bands of metal forming the outlines; 2. The champlevé enamel, in which the metal plate is chased out like a wood-cut, the cavities filled with enamel by means of fusion, and the lines of metal polished and gilt; 3. The enamel painting on plates covered with enamel of one color. These three forms, considered together, follow one another in point of time, but instead of showing any progress, they are marked by decline. The painted enamel, which is now almost always, and with very little solidity, used on their copper vessels with a dark blue ground, possesses on the whole but few charms. The best among them are plates and saucers of solid copper discs, covered with a rather thick white enamel, which is painted with flowers and ornaments, some of which are very neat, and of good style and disposition. Of the same kind are also whole tables and entire sets of articles for the toilet, which, however, only appear as abuses of the material and workmanship. Still the best and oldest specimens of this kind, though in fact they are but imitations of porcelain, are worthy of attention for museums and collections as well as for Art-Industry.

Of far more importance are the Chinese champlevé enamels, the production of which is especially to be attributed to the sixteenth and seventeenth centuries. These are not of copper, but bronze, destined for the altars in the houses of the nobles, and therefore of rare occurrence. They resemble the Renish and early Limoges enamelsof the twelfth and thirteenth centuries in workmanship and coloristic effect, but the forms and ornaments are in

the manner of the *Rococo* style, and therefore seldom of use to us. Far higher in both respects stands the earliest kindof the above-named cloisonné enamel of the middle ages. To this period, at least, belong the finest and most important objects; among them are some of great height, reaching even to 3 ft., and surprising specimens of freedom from those eccentricities which in some way or another usually characterize the art-productions of the Chinese. Many of these have been arranged by amateurs as lamps, while others as basins and flower pots form the charming ornaments of artistically arranged dwellings. Their chief excellence consists in their wonderful depth and richness of color, especially of a dark red, which the enamel manufacturers of Europe have never been successful in obtaining. The design, too, of these ornaments is seldom wild and capricious; at times naturalistic with splendid flowers, but frequently conventionalized somewhat after the Romanesque treatment. Such qualities, as soon as these vessels were brought to light, attracted the attention of French and English bronze manufacturers, but their imitations fall very far short of the originals in their artistic effect. The French imitations especially, which were to be seen in great numbers so early as in the Exhibition of 1867, have the one great fault of allowing too much space to the gilt bronze surfaces, so that the enamel is almost smothered, while it never attains the depth and strength of Chinese coloring. The effect they produce is merely that of dazzling the eye, they have no real elegance, and are quite destitute of the wonderful repose and harmony of the originals. In porcelains, too, the effect of their coloring has been attempted, and this not unsuccessfully, a proof how useful the study of them might be for modern industry in more ways than one.

Of still more importance, because of more general application, is the study of the Chinese bronze works. Their forms, indeed, even in the more ancient vessels are for the most part of the *Rococo* style, but their treatment is thoroughly admirable, and so perfect in cast and chasing, and so highly wrought, that they are perfectly wonderful. Added to this, we must note the varied tints and colors which the Chinese succeeded in giving to their bronzes from the darkest black and green brown to red and gold, a treatment of the surface which has confessedly given the impulse to a similar kind of bronze manufactures among the French. Moreover, the Eastern Asiatics, and especially the Japanese whose works in metal far surpass those of the Chinese of the present day, are acquainted with the art of silver damascening and practise it with surprising skill. Their bronze vessels, covered all over with ornaments of inlaid silver threads, which unfortunately seldom reach to us, because they do not belong to the usual articles of commerce, excite the admiration of connoisseurs, not only by the beauty and perfection of their workmanship, and their comparatively small price, but by the originality and energy of their composition. It is the same with works of a similar character in which the silver is not inserted in threads into the smooth surface, producing its effect by the design, but lies in high relief, forming ornamental patterns and figures which are composed and chased with all the boldness of Japanese art. The steel of their arms knives, and numerous small articles, is treated by them in the same manner. All these pieces of workmanship, so rife with instruction, are hitherto only to be met with in the possession of amateurs and private persons, and very seldom in public collections, in which are kept so many objects destitute of any artistic, any real value, but whi h have had the fortune to have seen the light so many hundred years ago instead of only yesterday.

The case is different with the Chinese and Japanese porcelain manufactures, the fame of which dates many centuries back, and which, by zealous imitation and the incitement of gain, for more than a century and a half, have given rise to a splendid and even flourishing and extending branch of industry. Our European porcelain is indebted for its origin, both as to art and material, to the Asiatics; only it has quitted the path which was æsthetically placed before it, and that not entirely to its advantage. This is the case, for example, with the color of the material and the material itself. The European porcelain very soon after its discovery made every effort to produce a material as purely white as possible, and the great manufacturers have by degrees succeeded in this point, which now offers no longer any difficulty. But it is a question whether

this is really an advantage, and not rather a sacrifice to the artistic side of the manufacture. The porcelains of China and Japan have never had this tendency, and if now, much of the Asiatic has almost or altogether the whiteness of the European, this is owing to the Chinese yielding to the taste of the Europeans in the way of business. The genuine, good old Chinese porcelain is always in the material itself slightly colored, either with a greenish or bluish tint, and this is one great reason why all these works possess a far greater degree of coloristic harmony. The purely white porcelain is in itself of no decorative quality, and if ornamented with color, the effect becomes hard and stiff. This is a point to which attention cannot be sufficiently directed, until it enters heart and soul into our present manufactures.

But this is not the only point for the sake of which we wish to turn the attention of our artisans once more to the porcelains of China and Japan; there are still a number of points of view and specialties on account of which they recommend themselves to our consideration. I grant that there is not much beauty in the ordinary articles of commerce, though some of them do possess considerable charms, or in many peculiar productions which amateurs hold in high esteem ; but when we go through such collections as that of the Japanese Museum in Dresden, either cursorily or with an attentive and intelligent eye, we cannot but be astonished at the multitude of variegated and happily executed ornaments, with which no modern exhibition, not even such as Sevres could produce in the last 10 or 20 years, can in any degree compete. It is of course, impossible for me here to go into any description, or even notification of the different kinds of decorative treatment ; I will only mention one, the simplest and perhaps the most appropriate of all, but which in our day has been almost entirely forgotten. I mean the blue china. Esteemed above all other in China and Japan for many centuries, it was very successfully imitated by us, in the 17th and the beginning of the 18th century, and but then, in consequence of the facility with which the porcelain received other colors, it fell into discredit. Yet, for the dinner table, which on account of the richness of its other appointments, cannot bear too much color, there is no better ornament, and it becomes one of the most charming decorations of a well-appointed dining-room, as is well known to amateurs and virtuosi, who are never tired of adding to their collections of blue porcelain or fayence.

In form, too, though at the first glance they appear of the *Rococo* caste, the Chinese porcelains are by no means to be despised. They even have more claims on our attention, inasmuch as our tea-services now in general use, derive their origin from them, and cannot deny their relationship, though it may be somewhat distant. In the mean time our artists have endeavored during the last 150 years to design and shape them in accordance with the prevalent style and the fashion of the day without effecting any improvement, and now, indeed, we hardly know what to make of them. It would not therefore be perhaps quite inappropriate, if we for once recognized their origin, for these old Chinese-Japan tea-services often display very agreeable forms and a physiognomy altogether original. It is the same with many other articles which might be rendered serviceable for ourselves if only an intelligent hand were to take them up, which thoroughly understood where and how to alter them.

There is one more branch of Eastern Asiatic Art ,namely, the lacquered work, which appears less directly applicable for our use, partly because it consists for the most part of articles of luxury, and partly because the distance between it and the European manufacture is too great ; and yet perhaps this last circumstance might only be a reason for our museums to collect specimens of those lacquered works, many of which are of really classical delicacy and execution. In what can all our tea-trays, cups, saucers, baskets, album covers, etc., not even excepting those of the Dutch and English imitation, compare with the manifold productions of the *Vieux Laque*, or even with the modern works of this branch of Oriental industry, which still are far behind their old models. In presence of that wonderful smoothness and finish which we feel to be so charming whenever we take one of these objects in our hands, of that lightness of material, and that unsurpassed accuracy of workmanship, that polish, and the variety and delicacy of the different tints and shades of the gold lacquer—in presence of all these charms, we forget the extraordinary forms,

and the quaint methods of decoration which frequently looks out for the most inappropriate and generally the most eccentric position for the chief ornament.

We might also discover in other branches of industry of those countries, many other excellences of which we might avail ourselves, if we would only overlook the oddness of their appearance and keep before our eyes what they have really good and worthy of recognition. Among other things there are their woven stuffs, from which many a happy motive may be gained, as from their paper hangings and their mural paintings, though these are of the most astonishing kind, for the Chinese artists are generally the more eccentric in design, the more highly they aspire, which is not the case with the Japanese. And lastly, and with especial emphasis, we would call attention to their embroidery, which, excellent in color, of just and maserly execution, is among the very best of modern productions of this natue. We think we have now said enough in this cursory notice, the object of which was to point out a new source from whence might be derived new motives, and what is so much needed, the renovation of modern taste and modern Art-Industy. The source flows indeed freely, but it must be wisely and carefully used.

ON AN AUTOMATIC DISCHARGE GAUGE.*

By THOMAS STEVENSON, F.R.S.E., M.I.C.E.

From "Engineering."

Next in importance to a knowledge of the rainfall of any district of country is the determination of the constant for absorption and evaporation. While the actual amount of rainfall is doubtless of value in meteorology, it is the available rainfall, or that which passes off the land, which is required to be known in all cases of water supply ; and it has also an important bearing on the subject of agriculture. This quantity varies with different localities, depending on the geological formation, the nature of the vegetation, and steepness of the slopes of the hills and mountains.

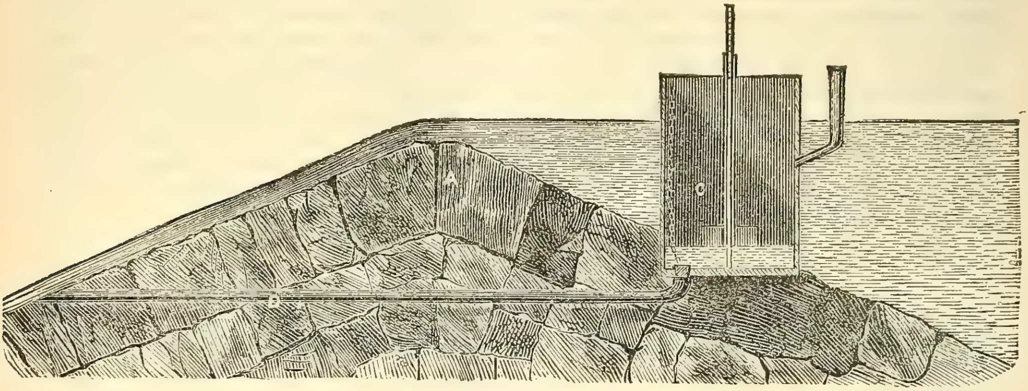
If a reservoir were of sufficient capacity to store up the whole of the available annual rainfall due to a given catchment area, we should then be able to obtain the required constant with perfect accuracy. This, however, probably exists nowhere, for in all reservoirs for the supply of towns a large quantity of water passes off by the waste weir or edgeboard, which is placed near the top of the embankment. The usual mode of ascertaining the quantity thus going to waste is by measuring once or twice a day during floods the level of the water above the top of the edgeboard, from which, by means of well-known formulæ, the quantity passing off is easily computed. It must be obvious that from such limited observations the quantity going to waste can only be very approximately ascertained, for the level of the water in the reservoir during floods is liable to great fluctuation.

Self-registering apparatus for indicating the variations in level, with the periods corresponding to such variations, might be formed by a float connected with a marker acting on a cylinder moved by clock-work. Another, and probably a simpler apparatus, was referred to by me at the last meeting of the Scottish Meteorological Society. Since then the details of the proposal have been drawn out and will now be described. A represents a cross section of a reservoir taken through the waste weir. B is a pipe perforated with small holes like a rose, the lowest hole in which is placed on the same level as the top of the edgeboard. A tube connects this with the tank, C, which has a float with graduated rod, and from this tank a pipe, D, with waste valve, is led through the waste weir.

Whenever the water in the reservoir rises to the level of the top of the edgeboard it begins to flow into the tank through the lowest perforation, and as the water rises it will pass through more of these holes, and thus the water which flows into the tank will remain a constant submultiple of what flows over the weir, and can be read by the sluice-keeper on the graduated rod. After the height of the float is read off, the tank is emptied by

*Paper read before Section G of the British Association.

opening the waste valve, when the water will escape over the down-stream side of the embankment, and the float will sink to zero on the graduated stem. The values of the readings on the graduated stem must be found experimentally before the instrument is used, by the immersion in water of the perforated tube at different levels, so as to ascertain the quantity passing through the holes at different levels of immersion. In order to prevent dust from choking up the small orifices,



a protecting tube should be placed over the rose tube. In a properly constructed reservoir the length of the waste weir should be so designed as never to have a greater height of water than 1 ft. or 18 in passing over it in heavy floods, so that the perforated tube need not be longer than about 18 in. The capacity of the tank must be proportioned to the size of the perforations in the tube (which should be arranged spirally) and the number of hours when the sluice-keeper is absent, which at the maximum will probably be from 9 P. M. to 6 or 7 A. M., which would require about 9 or 10 hours' storage.

ON THE DELIVERY OF WATER UNDER GREAT PRESSURES.'

By AMOS BOWMAN.

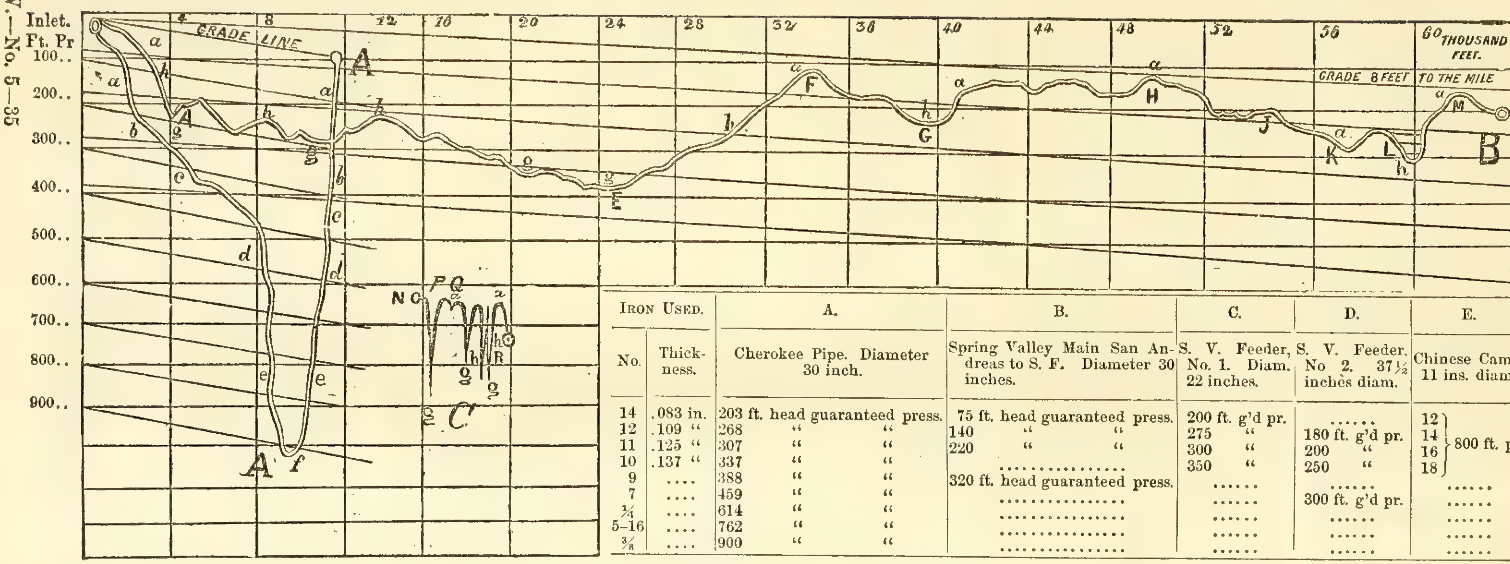
To set forth what has been done in a few well-known instances in California, in connection with suggestions originating in hydraulic mining, will be the most appropriate means of supporting our claim for having contributed valuable additions to the science of practical hydraulics. The necessity for carrying water over or through the greatest obstacles—over mountains and across sheer gulches of 900 to 1200 feet in depth, up again on the opposite side, and so to the locality where the water is needed, was the engineer's incitement; the object, gold, for the world's most urgent cry and demand; the results being a solution in the following facts, which are contributed for the use of engineers and practical men.

THE CASES A, B, C, D, AND E.

I select from sections furnished by Mr. Moore, of the Risdon Iron Works, under whose hand and judgment the leading works of this sort, in the State, have been executed, three leading ones, viz., the great Cherokee hydraulic mining pipe in Butte County, the Spring Valley main pipe from the San Mateo mountains to San Francisco, and one Spring Valley feeder; to which is appended a tabular statement of the dimensions of these and other pipes in actual present use, with facts touching durability, etc.

The Cherokee pipe is over two miles long, and has over 900 feet head and pressure; the Spring Valley is $14\frac{1}{2}$ miles long, and has in several places over 300 ft., and in one 350 ft., pressure; and the pipe at Chinese Camp (not represented in the following) is 9,000 ft. or $1\frac{3}{4}$ miles long, and has 800 ft. pressure.

The thickness of iron gives a basis for computing the comparative cost of cast iron and of wrought iron pipe; $\frac{3}{8}$ wrought



IRON USED. No.	Thickness.	A. Cherokee Pipe. Diameter 30 inch.	B. Spring Valley Main San Andreas to S. F. Diameter 30 inches.	C. S. V. Feeder, No. 1. Diam. 22 inches.	D. S. V. Feeder. No 2. 37½ inches diam.	E. Chinese Camp. 11 ins. diam.
14	.083 in.	203 ft. head guaranteed press.	75 ft. head guaranteed press.	200 ft. g'd pr.	......	12 } 800 ft. pr.
12	.109 "	268 " "	140 " "	275 "	180 ft. g'd pr.	14 } 800 ft. pr.
11	.125 "	307 " "	220 " "	300 "	200 "	16 } 800 ft. pr.
10	.137 "	337 " "	....	350 "	250 "	18 } 800 ft. pr.
9	....	388 " "	320 ft. head guaranteed press.	......	......	......
7	....	459 " "	....	......	300 ft. g'd pr.	......
¼	....	614 " "	....	......	......	......
5–16	....	762 " "	....	......	......	......
⅜	....	900 " "	....	......	......	......

SECTIONS OF WROUGHT IRON MINING AND SUPPLY PIPE.—*Location of Pipes.*—A. Cherokee Hydraulic Mining Pipe; capacity 1,900 Miners' inches, or 50 cubic feet per second. B. Spring Valley Main, San Andreas to S. F.; capacity 700,000 gallons per day. C. Spring Valley Feeder, No. 1; capacity 7,000,000 gallons per day. D. Spring Valley Feeder, No. 2. E. Chinese Camp.

Character of Iron Used at Various Heads.—*a.* No. 14 Iron. *b.* No. 12 Iron. *c.* No. 10 Iron. *d.* No. $\frac{1}{4}$ Iron. *e.* No. $\frac{5}{16}$ Iron. *f.* No. $\frac{3}{8}$ Iron. *g.* No. 9 Iron. *h.* No. 11 Iron.

Localities in Detail.—A. Caguchin Rancho. C. Road, Tanforan. D. 12-Mile School-house. E. 12-Mile Depot. F. Abbey Homestead. G. School-house Gulch. H. San Miguel. J. San Jose Railroad Crossing. K. Industrial School. L. Old Flume. M. Outlet at San Francisco. N. Inlet Spring Valley Feeder, No. 1 (C). P. San Andreas Valley. Q. 17-Mile House. R. Outlet near McMahon School-house.

iron sustaining a pressure of 385 lbs. to the sq. in., for which 3 in. cast iron (nearly) would be necessary for safety.

A carries 3,000 miners' inches with the head it has. The whole line of B is working perfectly, the limit run to being about half the pressure of the Cherokee pipe, arising from a necessity for a greater degree of safety.

The circumstances connected with the discovery of the practicability of such enormous heads in large conduit pipe, made of sheet iron, arose from the fact that in the engineers' formulas, and in practice everywhere, the tested safe pressure has always been accepted as the axiom; that is, the pressure a boiler would bear per sq. in., for example, without danger of explosion; but it was found necessary in connection with mining conditions, such as freightage in the mountains of California, to use thin, portable and cheap pipe; on which in using a higher and higher head was gradually used—since no great damage could result from bursting—until the limits became pretty well established amongst miners at a far higher figure than was ascribed to iron for other purposes.

Spring Valley being near San Francisco and in a populous county, the risks of damage from bursting would be far greater than in the mountains; it is for that reason that the Spring Valley pipe is made so much stronger, as seen in the table.

In proof of the utility of investments in pipe for mining, the Cherokee water used in one mine, is at the present time washing out $1,000 of gold per day. Quite a number of other similar new enterprises could be mentioned in this connection, were the subject in place; that at Cherokee involving, *en passant,* also a tunel for outlet, which will require five years to run.

To make use of the above figure, the method would be: that if a 23-in. pipe, for example, stands so much, a 12 in. pipe, or any other required, ought to bear so much less, the rule being that where the diameter is the same, the thickness of iron is as the height; or, where the height is the same, the thickness is as the diameter.

EXAMPLES OF DURABILITY.

1. Smartsville pipe, 16 in. diameter to 18 iron, not painted inside, painted outside, 180 ft. pressure, laid 1861—10 years.

2. Smartsville, 40 in. diameter, 3-16ths iron, with $\frac{1}{8}$ alternately, 2,200 ft. long, coated outside, laid 1861—10 years.

3. San Juan, 36 in. diameter, No. 12 and 14 iron, coated inside and out; pressure 55 ft.; running 10 years—estimated at 20 years.

4. Chinese Camp, 11 in. diameter, delivering 300 miners' inches. Nos. 12, 14, 16, and 18 iron; 9,000 ft. long; 800 ft. pressure; laid in 1868—2 years.

5. Cherokee—6 months.

The fractional expressions designating pipe or sheet iron are fractions of an inch; the numbers, as "No. 9 iron," refer to the English Ironmongers' gauge, an arbitrary system of designation, in which No. 11 is, for example, about equal to $\frac{1}{8}$ in. in thickness. (See Molesworth.)

RIVETING AND MANUFACTURING.

The following table gives items of importance concerning the riveting of the seams, the diameter of the rivets for each size of iron, and the distances between them, for both the longitudinal and the round seams.

No. of Iron.	Diam. of Rivets.	Distance between the Rivets.		
		Long. Seam, double riveted.		Round Seams.
		Horizontal.	Vertical.	
14	¼ inch.	1¼ inch.	⅝ inch.	⅞ in.
12	¼	1¼	⅝	⅞
11	5-16	1⅜	⅝	1
10	⅜	1½	⅝	1⅛
9	⅜	1¾	¾	1⅛
7	7-16	1⅞	1	1¼
¼	½	2¼	1¼	1½
5-16	⅝	2⅞	1¾	1⅞
⅜	¾	3¼	2	2¼

COMPARISONS OF WROUGHT AND CAST IRON.

Cast iron has some advantages over wrought iron. While weighing more, it will last from three to ten times as long, the iron being, for some unknown reason, less liable to oxidation. It is, when broken, worth one cent per lb., while wrought pipe iron is not worth cutting up in California. Anything above 16 or 18 in. would in all cases be better wrought; 24 to 30 in. of cast iron would be too expensive.

The city distributing pipes of the Spring Valley Co. are of cast iron; usually about

$\frac{3}{4}$ in. in thickness, which is four or five times the quantity of iron that would be necessary if the same were wrought instead of cast.

A 2 horse team will walk along freely with 250 ft. of 18 in. wrought iron pipe; while 20 ft. more or less of cast iron would make a sufficient load for them.

IRON AND STEEL NOTES.

Machine Puddling—Is the finished iron trade just within reach of that of which they have been so long in quest? It really seems like it; and yet the news appears too good to be true. The problem will, however, soon have its solution. We shall then know if in the United States there is at work a rotary puddling-furnace which, although not very different from that with which Mr. Menelaus has been experimenting, yet has distinguished itself with the important difference of having been a success, whilst the British machine cannot be so regarded. It will be some consolation for men who have nationality jealousies, that if all that is claimed for Mr. Danks's machine should prove true, then that Mr. Danks, if we are not misinformed, is not an American, but an Englishman. Our information is that Mr. Danks is a native of the Black Country, and that in early life he was actively engaged in iron manufacture about Dudley and West Bromwich. But whether this be so or not, and we mention it only that a yet closer interest may thereby be invoked in what he has done, Mr. Danks has deported himself in reference to his invention in the frankest possible manner. The paper that he contributed to the recent meeting of the Iron and Steel Istitute, and the explanation with which he accompanied it, all of which was reported in the Supplement to the Journal of September 2, will go far to make the meeting in Dudley more memorable in the history of the iron trade than that meeting in Cheltenham, at which Mr. Bessemer read to the British Association his famous paper, will prove to the steel trade. It was impossible to resist the conviction that Mr. Danks had been most straightforward. The report that we supplied at the time will have conveyed that impression to every reader. Much deeper will that impression have been made upon the minds of those who listened to Mr. Danks. Side by side with that of which most of us have knowledge, in reference to some inventions of American origin, and in respect of some American inventors, this is most encouraging at the present stage of the inquiry. To the uncertainty which too often overhangs the English mind on such matters, and to the good reason there often is for it, Mr. Menelaus bore testimony before Mr. Danks got up, when he remarked that without at all disputing that Mr. Danks had accomplished all to which he laid claim, he could not forget that some time ago an American inventor was at the Dowlais Works for about a year, receiving all the help that the firm could afford him, yet he was unable to make anything else than a miserable failure of that which it had been said was a splendid success in America. Whilst such experiences reasonably make the British iron master cautious, they do not prevent him from looking with hope, amounting almost to confidence, to the result of the inquires that he is about himself to institute into the merits of the new claimant for his favor.

Mr. Danks has not brought his invention under the notice of the iron trade of Great Britain before it has been well tested in the States. His paper furnishes particulars enough of the extent to which his machine has supplanted the old hand-puddling furnaces. But independent testimony comes direct from the States to conspicuous members of the industry here. Mr. Walter Williams, the honorable Secretary of the Iron masters' Association of South Staffordshire, has a considerable experience of the finished iron trade, not only from a life-long practical acquaintance with it at home, but from careful observation of what is being done as well throughout the States as in those portions of the continent of Europe that are open to the inspection and the visits of the English ironmaster. He has been seeking to solve the machine-puddling problem. About to examine and pronounce upon the drawings of such an apparatus that had been submitted to him, he has been arrested by a message from the New World, of which the following is the pith:—"Withold your judgment on the mechanical puddler; Danks, a man in Cincinnati, has got a complete success." Better than this, Mr. Hewitt, one of the most accomplished members of the American iron trade, bears testimony in its favor. He, too, declares it a success, and enforces the testimony by adopting the machine in the place of the old furnace at an establishment in which he is pecuniarily interested. Hardly any room is, therefore, left for doubt that there is full truth in the asseveration of Mr. Danks himself, to the effect that the machine is "as truly a success as that the members of the Iron and Steel Institute are men."

Assuming, then, that in America they have taken the one step that in England we have halted at, the inquiry arises—can that one step be taken here? That one step is an enduring lining. As to Danks's machine, and the machine which is the invention of Mr. B. P. Walker, of Wolverhampton, with which, as the purchaser of the patent rights Mr. Menelaus has been experimenting, we agree in great part with Mr. E. Williams. That gentleman remarked that looking at Mr. Danks's machine with the eye of a practical man, he did not see anything in which it was likely to differ from what could be effected with the Dowlais machine, with Mr. Menelaus at the end of it. But Mr. Williams could not see the initial lining, to which Mr. Danks's success is almost entirely owing, and at which, he asserts, after it has been once applied, you may "fire till doomsday without destroying it.' It was the want of such a lining that defeated Mr. Menelaus. Mr. Danks finds in America a certain native mountain ore. Its value consists in this—that it contains a very small per cent. of silica. Any ore, Mr. Danks affirms, that contains no more than 5 per cent. of that ingredient will effect the purpose. Whilst it is for our own iron trade, we take it, and not for Mr. Danks, to find such a material, still that genleman points out that he has seen in this country a Norwegian iron ore that contains even a smaller percentage of silica than 5 per cent., which seemed to him to be suitable for the purpose.

Upon being told that tap cinder contained only 2 per cent of silica, Mr. Danks expressed his belief that that would accomplish the purpose. He may be right with reference to the Norwegian ore, but we think he spoke without sufficient informa-

tion when he testified in favor of tap cinder. Our own experience of the bulk of tap cinder is that it contains a larger proportion of silica than is here indicated ; and, next, we know that before Walker's machine passed into the hands of Mr. Menelaus tap cinder was tried for a lining and failed. But tap cinder and Norwegian ore, and any other material that suggests itself to them, the deputation of the Puddling Committee of the Iron and Steel Institute may take to America, and with it any and every kind of pig iron used in this country, and there, as we understand, with Mr. Danks himself to assist them, put lining ingredients and raw material to such a practical test as will enable them fully to report upon the merits or demerits of the machine in its application to the finished iron manufacture of the United Kingdom. It is hardly needful to say that the trade has confidence that the Committee will make their experiments in every way thoroughly, so that nothing shall remain to be decided by experiments on this side, inasmuch as to conduct thorough experiments in this country would involve a pecuniary outlay of no inconsiderable extent. In the interest of the great national industry affected, we look for further information from the Committee with much expectation.

Since the above was written the following has been made known: The Puddling Committee met last week, and decided to send out a Commission of three gentlemen. Mr. G. J. Smelus, of Dowlais, and Mr. J. A. Jones, of Middlesborough, were requested to form two of the Commissioners, and the selection of a third gentleman was left to the South Staffordshire ironmasters. The Commissioners will take with them 10 tons each of Welsh, Cleveland, South Staffordshire, and Derbyshire pig iron, together with fettling available in this country. They are expected to sail in about 10 days, and will be accompanied by Mr. Danks himself. They will receive their instructions previous to starting, as the Puddling Committee have arranged to meet them at Liverpool the day before they sail. In case the Commissioners should send a favorable preliminary report, it is quite probable that arrangements will be made for putting up an experimental furnace and appliances in England for the purpose of thoroughly testing the plan. A number of firms have already expressed their willingness to find the needful funds, Mr. Danks making arrangements for allowing the cost off royalties that may accrue in England.—*Mining Journal.*

THE ACTION OF WATER ON IRON.—Mr. Sainte-Claire Deville subjected perfectly pure iron to the action of water vapor of known tension and temperature, at the same time maintaining the temperature of the iron constant throughout each experiment. The apparatus he employed was a porcelain tube, to contain the iron communicating at one end with a glass retort, which furnished the water-vapor, and at the other with a manometer. Arrangements were made to exhaust the apparatus by a Sprengel pump, or to pass through it hydrogen or other gases. Constant temperatures were obtained by the use of an oil or a mercury bath, or by the vapors of boiling mercury, sulphur, cadmium, or zinc, the respective temperatures of which are 360 deg., 440 deg., 860 deg., and 1040 deg. Cent. With the apparatus he found —1. That iron continues to oxidize in water-vapor, until at a fixed temperature the tension of the hydrogen set free becomes constant.—2. At the point of maximum tension for any given temperature, lessening the pressure by withdrawal of some of the hydrogen, causes a renewal of the action of the iron on the vapor, which continues till the constant is restored ; or if hydrogen is sent into the apparatus, so that the pressure is increased beyond the constant value, some oxide of iron is reduced, and the pressure restored by the condensation of the water thus formed.—3. When heat is applied to the apparatus, the tension is preserved by the *condensation* of some of the hydrogen on the oxide of iron.—4. When the temperature of the vapor is maintained the same, but that of the iron is made to vary, the tension of the hydrogen is less as the temperature of the iron increases. At 200 deg. Cent. the tension of the moist hydrogen = 100 mm.; at 260 deg. it is 68.8 mm.; at 360 deg., 45 mm.; at 440 deg., 30.4 mm.; at 860 deg., 17.7 mm.; at 1040 deg., 13.5 mm.; and at the melting point of iron, 9.7 mm.—5. The higher the tension of the water-vapor, the temperature of the iron remaining the same, the higher is the tension of the hydrogen, and as the tension of the vapor increases, the increase of tension of the gas is more than proportionate, the difference of increase becoming less and less, however, as the temperature of the iron is raised.—6. All these laws hold good when a small quantity of hydrogen is allowed to act on a large quantity of oxide of iron. M. Sainte-Claire Deville also accounts for the singular erosion of the iron of steam-boilers by distilled water, by the fact that iron is slowly attacked by steam at 150 deg. Cent. The oxide formed by steam acting on iron at the temperature of 440 deg. Cent. has a composition corresponding to $Fe^4 O^5$; it is amorphous, black, magnetic, is scarcely affected by nitric or sulphuric acids, but is readily soluble in cold hydrochloric acid, forming a deep brown solution, with which potash forms a black precipitate. The remarkable fact is thus clearly elicited, that iron is much more acted on at low temperatures than at high ones.—*Mining Journal.*

RAILWAY IRON IN BRITISH AMERICA.—The great demand for railway iron which has been provoked by the revival of railway enterprise in British America still continues apparently unchecked. This will be seen by an examination of the exports of railway iron from the United Kingdom month by month this year in the direction indicated :

Month.	1869.	1870.	1871.
January..........Tons	110	—	100
February	1,113	750	—
March	2,224	2,583	2,607
April	4,756	5,371	5,929
May	4,789	3,450	6,077
June	4,618	3,495	12,566
July	1,648	6,763	9,859
August	3,356	2,589	10,976
Total	22,614	25,001	48,114

This increase in the demand in a long stagnant quarter has been one of the most encouraging features this year in the iron trade. It has compensated, in some degree, for the decline in the consumption of railway iron in India, and it is also valuable, inasmuch as it augurs a still larger demand in the future. At present, the work of railway construction is being hurried on in Canada, the principal new lines on hand being the Intercolonial, the air-line of the Great Western Railway

of Canada; the Canada Southern; the Wellington, Grey, and Bruce; the Toronto, Grey, and Bruce; the Toronto and Lake Nipising; the Toronto, Simcoe, and Muskoka Junction; the North Grey; the Canada Central, etc. Of these lines the most important is beyond all doubt the Intercolonial Railway, and although this line has reached at present only an imperfect stage of development, it has made sufficient progress to justify the anticipation that it will be distinguished by a high degree of stability and excellence. The rails are of the best English steel, weighing 64 lbs. to the yard, and they are suited to resist the heaviest traffic, and to admit of the highest speed. All the bridges, with 3 exceptions, will be constructed of iron; these 3 were too far advanced before the arguments of Mr. Fleming, the chief engineer, prevailed; but there will be no difficulty in replacing the wooden bridges at Rivière du Loup and two other smaller ones with iron, as the piers throughout are of solid masonry. A great quantity of steel rails and rolling stock have been accumulated for the Intercolonial system, which will be in working order by the close of 1872 or the commencement of 1873. The line will be steel-railed throughout, and this policy on the part of the Commissioners who have been intrusted with the great work, marks an epoch in the railway history of Canada. Hitherto Canadian railway enterprise has been crippled by the enormous cost of renewals and maintenance, but the Intercolonial Railway Commissioners have profited by experience, and have resolved to get rid of this difficulty altogether by laying steel rails at the outset. The example will, no doubt, be followed with all practicable speed by the other chief Canadian railways—certainly by the Grand Trunk and the Great Western of Canada. The Grand Trunk once steel-railed, and the cost of maintenance once brought down to a reasonable level, the position of its long-suffering share and bond holders will be greatly changed, and they will enjoy at last a fair return upon their capital. If this result could be attained, we believe it would prove highly beneficial to Canada generally, as every disappointed Grand Trunk investor has naturally become a severe critic of everything Canadian. With an improvement in Canadian railway credit, there would be an improvement in Canadian affairs generally, and although anything like precipitation in railway construction is to be deprecated, as well in Canada as in other parts of the world, the regeneration of the Grand Trunk would, doubtless, give a still further impetus to Canadian railway enterprise. The reduction in the cost of steel rails and the severity of the Canadian winters render certain a large Canadian de mand for the new essential element in a thoroughly sound permanent way. Further, we may expect that the Canadian demand for railway iron—a phrase which must, of course, be taken to include steel rails—will be augmented, from the fact that Canada is only now becoming a great power in the world. So long as the mother country cared little about her colonies, but was engrossed with her great struggle against Napoleon Bonaparte, so long as Canada was disunited and torn by intestine convulsions, so long as Canada remained poor and English capitalists remained short-sighted, so long Canada languished on without much effort to turn her great natural resources to account. But all this is changed. The Canada of to-day is being riddled with railways, whilst she is mapping out more; she has united her scattered provinces, and with the strong arms and stout hearts which she is now seeking on this side of the Atlantic, she bids fair to expand into one of the first nations of the earth.

A new puddling and heating furnace, invented by a Mr. Howatson, is exciting considerable attention at the Dudley Iron Works, England, where it is being introduced. The specialty of the furnace consists in supplying hot instead of cold air to the grates of the puddling and heating furnaces, and it is said that in one year coal and iron to the value of £187 may be saved in a puddling furnace, and over £450 in a 12-inch mill heating furnace, by its use. The ash pit of the furnace is closed by a door, and the opening of the grate is also closed in the same manner, the air required for the combustion of the fuel being obtained through flues below the chimney stack passing underneath the heating chamber. The waste heat from the furnace is made to heat the base of the stack, and this, together with the heat from the furnace, raises the temperature of the air for combustion to a high point. It was mentioned that this patent heating furnace has been tried at the Earl of Dudley's Round Oak Ironworks, under the superintendence of the manager, Mr. R. S. Casson. In one week of ten turns, when a 12-in. mill furnace had got into regular working order, the exact result was as follows: A saving of 5 tons 18 cwt. 0 qrs. 17 lbs. of coal, 1 ton 2 cwt. 1 qr. 3 lbs. of iron, and a loss of 2 tons 8 cwt. 2 qrs. 3 lbs. of cinder, the decrease in the latter amount being accounted for by the saving in the iron. The furnace has worked better, the iron being sooner and more uniformly heated, the labor of the furnace-men is diminished, as less firing is required, and there is every appearance that the brick lining will last much longer than is usual with the ordinary apparatus. A puddling furnace has recently been tested at Mr. Thomas Vaughan's, Bishop Auckland Iron Works, and there was a saving during the first week it was in operation of 4 cwt. 0 qrs. 9 lbs. of coal, and 2 qrs. 0 lbs. of iron per ton of puddled bar made. The results now are still more favorable, and the saving of coal is over 5 cwt. per ton. Neither of the furnaces above mentioned were furnished with the arrangement for consuming smoke, or no doubt a much greater saving would have been accomplished. There was not a melting chamber attached to Mr. Vaughan's furnace, because of the prejudice of the men, which it was thought would lead them to tamper with the appliances. At some future trial it is intended to complete the apparatus. The inventor accounts for the great saving as follows: By heating the atmospheric air from the furnace itself, a saving would be effected of something like 25 per cent. over the old method, for it is natural to suppose that the cold air is robbing the furnace of so much necessary heat, which must be again supplied at the expense of extra fuel. There can scarcely be any doubt that the quantity of heat taken up is waste heat, but that would not account for the whole of the saving, were the total amount of heat taken in by the air got at no expense of fuel. He considered the reason lies in the superiority of hot over cold air for the consumption of fuel; the advantages of which are to be noticed in the application of the former to the blast furnace.

The only effect the heat has upon air is to ex-

pand it, and when this is done there is a much less weight of oxygen for a given volume, than in cold air; and the latter, therefore, containing the largest amount of the supporter of combustion, might be taken to compensate for the sensible heat of the rarefied air. Oxygen, when heated, combines more readily with the incandescent carbon in the grate of the puddling furnace, and this is, perhaps, because it enters the fire at nearly the temperature required for combustion, so that it does not rob the already burning fuel of the heat necessary to raise it to this degree. In the ordinary furnace, when cold air is supplied immediately under the bars of the grate, it expands on entering the fire, and takes up a quantity of available heat to raise it to the temperature it finds in the furnace. In the improved furnace, however, a much smaller grate answers the purpose, and this leads to a still further saving; for in the ordinary apparatus, with so large a grate, and fired as it is from a small door in the side, it is almost impossible to distribute the fuel fairly over the whole surface, and at times there will be places where the layer of fuel is thin, and others where it is not covered at all. Through these places, large quantities of cold air are drawn, which, mixing with the other gases, has a tendency to cool the furnace. This causes waste of the iron by oxidation. In the patent furnace, there is less grate area, and less opportunity for the passage of air, and that coming under is readily consumed. The result is a small loss of iron and a great saving of fuel. The melting chamber also saves both time and fuel. There is also an apparatus for consuming smoke connected with the invention, which leads to a still greater saving of fuel.

RAILWAY NOTES.

THE RAILWAY OVER MONT CENIS.—The following extract from Mr. Whymper's "Scrambles Amongst the Alps" may be interesting to our readers as a popular account of the Fell Railway as viewed by unprofessional eyes:—The railway itself is a marvel. For 15¾ miles it has steeper gradients than one in 15. In some places it is 1 in 12½! An incline at this angle, starting from the base of the Nelson Column in Trafalgar square, would reach the top of St. Paul's Cathedral if it were placed at Temple Bar! A straight piece of railway constructed on such a gradient seems to go up a steep hill. 1 in 80, or even 1 in a 100, produces a very sensible diminution in the pace of a light train drawn by an ordinary locomotive; how, then, is a train to be taken up an incline that is 6 times as steep? It is accomplished by means of a third rail placed midway between the two ordinary ones, and elevated above them. The engines are provided with two pairs of horizontal driving-wheels as well as with the ordinary coupled vertical ones, and the power of the machine is thus enormously increased; the horizontal wheels gripping the centre rail with great tenacity by being brought together, and being almost incapable of slipping, like the ordinary wheels when on even a moderate gradient. The third rail is the ordinary double-headed rail, and is laid horizontally; it is bolted down to wrought iron chairs 3 ft. apart, which are fixed by common coach-screws to a longitudinal sleeper, laid upon the usual transverse ones; the sleepers are attached to each other by fang-bolts. The run across the top of the pass from the Summit station to the Grande Croix station—a distance of about five miles—is soon accomplished, and then the tremendous descent to Susa is commenced. This, as seen from the engine, is little less than terrific. A large part of this section is covered in, and the curves succeed one another in a manner unknown on any other line. From the outside the line looks more like a monstrous serpent than a railway. Inside one can see but a few yards ahead, the curves are so sharp, and the rails are nearly invisible. The engine vibrates, oscillates, and bounds; it is a matter of difficulty to hold on. Then, on emerging into the open air, one looks down some 3,000 ft. or 4,000 ft. of precipice and steep mountain side. The next moment the engine turns suddenly to the left, and driver and stoker have to grip firmly to avoid being left behind: the next, it turns as suddenly to the right; the next there is an accession or diminution of speed, from a change in the gradient. An ordinary engine, moving at 50 miles an hour, with a train behind it, is not usually very steady, but its motion is a trifle compared with that of a Fell engine when running down hill. It may be supposed from this that travelling over the Fell railway is disagreeable rather than pleasant. It is not so; the train is steady enough, and the carriages have remarkably little motion. Outside they resemble the cars on the Swiss and American lines; they are entered at the end, and the seats are arranged omibus-fashion, down the length of the carriage. Each carriage has a guard and two brakes—an ordinary one, and a centre rail brake; the handles by which they are worked come close together on the platform at one end of the carriage, and are easily worked by one man. The steadiness of the train is chiefly due to these centre rail brakes. They greatly diminish the up-and-down motion, and render oscillation almost impossible. The steadiness of the train is still further maintained by pairs of flanged guide-wheels under each of the carriages, which, on a staight piece of line, barely touch the centre rail, but press upon it directly there is the least deviation towards either side. There is no occasion to use the other brakes when the centre rail brakes are on; the wheels of the carriages are not stopped, but revolve freely, and consequently do not suffer the deterioration which would otherwise result. The steam is shut off and the brakes are applied a very few minutes after beginning the descent to Susa. The train might then run down for the entire distance by its own weight. In practice it is difficult to apply the proper amount of retardation; the brakes have frequently to be whistled off, and sometimes it is necessary to steam down against them. Theoretically, this ought not of course to occur; it only happens occasionally, and ordinarily the train goes down with the steam shut off, and with the centre rail brakes screwed up moderately. When an average train—that is, 2 or 3 carriages and a luggage van – is running down at the maximum speed allowed (15 miles an hour), the brakes can pull it up dead within 70 yards. The pace is properly kept down to a low point in descending, and doing so, combined with the knowledge that the brake power can easily lessen it, will tend to make the public look favorably on what might otherwise be considered a dangerous innovation. The engines also are provided with the centre rail brake, on a pattern somewhat different from those on the carriages, and the flat

sides which press against the rails are renewed every journey. It is highly desirable that they should be, for a single run from Lanslebourg to Susa grinds a groove into about $\frac{3}{8}$ of an in. in depth. Driving the trains over the summit section requires the most constant attention and no small amount of nerve, and the drivers, who are all English, have well earned their money at the end of their run. Their opinion of the line was concisely and forcibly expressed to me by one of them in last August: "Yes, mister, they told us as how the line was very steep, but they didn't say that the engine would be on one curve, when the fourgon was on another, and the carriages was on a third. Them gradients, too, mister, they says they are 1 in 12, but I think they are 1 in 10, at the least, and they didn't say how we was to come down them in that snakewise fashion. It's worse than the G. I. P., mister; there a fellow could jump off; but here, in them covered ways, there ain't no place to jump to."—*Engineer.*

American Street Cars Abroad.—During the past 3 or 4 years the builders of street cars in this and neighboring cities have enjoyed a large and profitable business in filling orders from all parts of the world, and the demands from foreign countries are steadily increasing. Cars built in this city are now in use in Belgium, Denmark, London, Liverpool, Glasgow, Birkenhead, and many other of the principal cities of the United Kingdom, Australia, etc., and recently proposals have been invited from a Russian company for cars to be run in the streets of Moscow. But our market for street cars is not limitted to Europe. Within the past year or two several horse railroads in Brazil have been supplied with cars built in New York factories. Other South American countries have also adopted the horse railroad system, and one large establishment in this city has furnished the cars for 6 lines in Buenos Ayres, 4 in Rio Janeiro, 2 in Bolivia, and 4 in Para and Pernambuco. Orders have also been filled for Chili and Peru, and others are in hand for San Paulo. None, we believe, have yet been sent to Lima; but the question of building horse railroads has been under consideration in that and neighboring cities for some time past, and the results accomplished by them elsewhere will, doubtless, soon decide the debated point in favor of a trial of the system. An extensive trade has sprung up lately with the countries named in rails, machinery, tools, and other necessary materials in railroad construction and operations. This trade, which has been built up in spite of British competition, promises a steady and rapid development, the excellence of the articles of this class exported assuring us a permanent hold upon the markets to which they have already found admission, and opening the way for their more ready introduction into others where no demand for them now exists.

Cast Iron Railroads.—A novel use for cast iron has been introduced in Scotland, which is the adoption of the metal for railroads and tramways, at least thus far to a limited extent. At a meeting of the trustees of the Clyde Navigation Company, of Glasgow, the engineer reported that a cast-iron tramway which had been laid down on the South Quay for trial, had stood in a most satisfactory manner the most severe tests for more than 4 months. During this period the passing of railway and cart traffic had been almost continuous, but the tramway showed no signs, either displacement in line or level, or of any wear or need of repair in any way, being, to all intents and purposes, as perfect as when first laid down. Under the circumstances of the severe tests to which the tramway had been submitted, the results were considered highly satisfactory, and the further use of this style of roadway was recommended. Cast iron tramways are, therefore, to be laid upon all the quays and yards of the Navigation Company in Glasgow, with a prospect of good results and great economy. Here is an opportunity for American inventors in the street railway line.—*Iron Age.*

Northern Pacific Surveys.—The Kalama (W. Ter.) "Beacon" says: "A full party under Capt. J. R. Maxwell is at the Snoqualmie Pass, running a line down the Yakima, east, extending that surveyed last summer west from the Pass toward Puget Sound. Another party, under Hubert C. Ward, Assistant Engineer, has just finished locating the next 40 miles north of the 25 under construction; which 40 miles is upon the portage between the Lower Columbia and Puget Sound, and brings the western line within 17 miles of the waters of the 'Sound.'

"A party under Mr. Eastwick, Assistant Engineer, is also making a full survey up the Clearwater by the south fork, over the Bitterroot Mountain into Montana. A Barometrical party, under Mr. Chas. A White, Assistant Engineer, is to proceed to the Pend d'Oreille Lake, and explore the country toward the Passes of tbe Cascades, southwesterly.

"The Northern Pacific have wisely determined to make no mistakes in location for want of complete and exhaustive explorations and surveys. Camps are being built, and parties are organizing to commence grubbing and clearing upon the 40 miles located, which work is to be kept out of the way of a large grading force to commence on the grade early next season.

"Construction parties are upon ths 25 miles under Resident Engineer F. Hinckley, which is being pushed with a *vim* to its completion by November 1st. The iron for the 25 miles is at Kalama, the ties are being distributed, and 2 locomotives are *en route* from San Francisco. The bridges are being rapidly constructed.

Underground Railroading.—In the construction of the Underground Railway in London, a part of the route extended under the Church of St. Nicholas, and to support the building while the the excavations were going on, the following plan was adopted: At intervals in front of the walls of the church, wells of the diameter of $3\frac{1}{2}$ ft. were sunk to the depths of 40 ft., and these wells were then filled in with brick-work and cement. The same method was adopted to support a tall chimney stack in the neighborhood, and in both cases the old and new structures remained firm. Cuttings in another portion of the line were made through a mass of human bones 16 ft. thick, which were the remains of an old and disused burial ground. In the construction of the station at Cannon street, 2,000 workmen were employed, for nearly 4 months, within a space of 280 sq. yards, and 150,000 tons of earth and rubbish were removed, while 50,000 tons of new material were brought upon the ground.—*Chicago Railway Review.*

DENVER & RIO GRANDE NARROW GAUGE.—The Denver "Tribune" (16th) says that on the 15th the track-layers reached the 33d mile post, 2 miles beyond Citidal (or Castle Rock) station; 10 more cars of iron were received and forwarded to the front. Track iron is accumulating at St. Louis. Sidings have been put in at 3 stations. A very noticeable and probably gratifying thing to the officers of the road, is the traffic already enjoyed by the line. An average of 12 or 15 car-loads of lumber and wood are brought to Denver every day. The Company has a contract for delivering to this point 750,000 ft. of lumber for Kansas Pacific snow-sheds, to be built between Carson and Wallace. There are also 2,000 cords of wood awaiting shipment. The first stock shipment from one point was to have arrived the 15th, designed for exhibition at the fair, at Denver. Passenger cars leave daily, and are well filled—rather contrary to general expectations so early in the day of this road's operations. The telegraph line is being constructed. The poles are set to the end of the track, and the wire will be put up at once.

PAINSVILLE & YOUNGSTOWN (OHIO).—The "Iron World" says that New Yorkers are now building a 3-ft. gauge road from Painsville to Chardon, Warren, and Niles, on to Youngstown, Ohio, and that a company is organized to build a 3-ft. gauge from Leetonia to Hazleton, the greater portion being now graded and ready for the iron.

ENGINEERING STRUCTURES.

ENGINEERING WORK IN NEW YORK HARBOR.—For many years the removal of the obstructions to safe navigation at Hell Gate in the harbor of New York has been attempted with more or less success. From present appearances we should judge these attempts are finally to be crowned with success. Recently, General Humphreys, Engineer-in-Chief of the United States Army, accompanied by the Secretary of War, Generals Sherman, McDowell, Ingalls, Newton, and a host of other military men, visited the scene of the work, and inspected operations. Two years ago, Gen. Newton began the great work—that of removing rock obstructions between Hallet's Island and the land opposite, thus securing a safe, short, and important entrance to the harbor for vessels of large size. When Gen. Newton began this gigantic undertaking, he found that there were 3 acres of solid rock to be removed. Sinking a shaft to the water's edge, he marked out 10 immense cuttings, or alleyways, at equal distances of 15 ft. Some of these cuttings have been bored under the river from 50 to 140 ft. The excursion party descended into the shaft, and went far into one of the cuttings. The water dripped liberally through the roof of the alleys, sometimes in such quantities that suits of water-proof were necessary. The miners cut under the bed of the river, leaving huge pillars to support the roof above. In the alleys a line of rails is laid down, on which by cars the stone taken out is conveyed to the shaft and lifted to the surface. Despite the hardness of the quartz rock, the miners progress at the rate of 15 ft. per month. Air compressing machines are erected on the surface of the pit, and are connected with each of the 10 passages by pipes, at the end of which a machine will be attached to work a drill. This is the same arrangement adopted in boring the Mont Cenis tunnel. The distinguished military party were treated to a series of blasts, which quite astonished them, and gave them new ideas of the power of nitro-glycerine. Gen. Newton's plan for entirely removing the obstructions is as follows: When the entire distance has been excavated, and all the cross sections and pillars have been cut, or reduced to the smallest size, he proposes to blow up the 3 acres of rock all at once. Everything is to be filled with nitro-glycerine; all the apertures in which the exploding material is placed will be connected with electric wires; then the water will be let into all the passages and cover everything; the battery will explode the whole mass at the same moment, and all the rock will sink down into the alleys cut beneath, leaving a splendid passage for shipping of any tonnage.—*American Railway Times.*

THE SHA-WEI-SHAN LIGHTHOUSE, CHINA.—The island of Sha-wei-shan is situated at the mouth of the Yang-tsze river, opposite to the Tsung-ming, or north channel branch, in latitude N. 32 deg. 24½ min., and longitude E. 122 deg. 14¼ min. All vessels trading between Shanghai and the northern ports of China have to pass this island, which lies right in their course, and there has been very generally felt the want of a lighthouse upon it. The Tsung-ming channel has long been used by native craft, and now a few of the light draught steamers occasionally use it. The channel generally used, however, is the southern one, and vessels bound north go round the Tungsha light vessel before the course for Sha-wei-shan is steered.

In the beginning of last year designs and estimates were prepared by Mr. David M. Henderson, C.E., the chief lighthouse engineer, for this lighthouse, and shortly afterwards Mr. Robert Hart, the inspector-general of the Imperial Maritime Customs, sanctioned the prosecution of the works. The tower, lantern, and light were ordered in England by Captain Forbes, R.N., who at that time was marine commissioner, but has since resigned. In the autumn a few natives were sent to clear away the dense mass of trees entwined with creepers that were growing on the top of the island, and to cut pathways up two of its sides, which are exceedingly steep. The island is about 600 yards long, 300 yards broad, and 190 ft. high, with a narrow ridge on the top, that had to be cut down to afford space for the light-keepers' dwellings. On the 1st of January of the present year a European foreman landed with a number of natives, and put up the huts for the working party. A Henderson's steam-derrick crane, manufactured by the Messrs. D. Cameron & Co., of Glasgow, was erected on a cliff 50 ft. high, at the south-east corner of the island, rendering the landing of the heavy materials a simple operation, even in a heavy swell. The water for the building operations and working party was partly obtained by spreading out the corrugated iron, which was afterwards to be used for the roof, on a framework of bamboos, and the ridge pieces, when inverted, served as gutters to conduct the rain water into casks buried in the soil. On a few favorable places on the rocks narrow ridges of Portland cement guided the surface water into reservoirs of bricks, which were rendered water-tight by being backed with puddled clay, and plastered with ce-

ment. As a further precaution in case of there being little rain, a condenser extemporized out of gas pipe was attached to the boiler of the steam crane. On one occasion, when short of water, it was tried, and produced about 250 gallons of water in 9 working hours. The water for the light-keepers is stored in brick tanks, set and plastered with cement, of a total capacity of 2,400 gallons.

The island is very much exposed, being out of sight of the mainland, and in the event of a gale of wind the tender had to run for shelter inside of the Tung-sha light-vessel, which is 20 miles distant. The port of Shanghai, from whence all the building materials were procured, is 64 nautical miles distant. The light materials were landed in ordinary ships' boats, and a fish boat of about 5 tons capacity was ready to land the heavy cargo. The whole of the plates for the tower and base course of granite were stowed in a Chinese lorcha, which was towed to the island by the steam tender, and as a favorable opportunity occurred a temporary buoy was moored off the landing place, and the lorcha was hauled alongside the rocks under the steam crane, discharged, ballasted, and hauled off safely without the slightest damage. When the tower was erected, the whole of the light and lantern were taken in the Relief, a sailing tender, and landed at one time. In this case the wole afternoon of the 10th of May was expended in getting the tender under the crane, on account of the strong tide and swell that was on, and at 6 o'clock her crew wanted to haul out to sea for the night. The men had some food given to them, and at half-past 6 o'clock the first case was landed. By 11 P.M. the whole was safely landed, and the tender hauled off to the buoy. At 5 A.M. the following morning, a gale of wind was blowing, and a clear out had to be made.

The whole of the works were executed by natives, under Mr. Henderson's superintendence, with the assistance of an English foreman and mechanic. The light was first exhibited at sunset on the 1st of July. The optical apparatus is a catadioptric one of the first order, showing a fixed white light all round the horizon, and having its centre 229 ft. above high water, so that in clear weather it will be visible 22 nautical miles. The tower is painted black, and the light-keepers' dwellings are white. The house is built of brick, at a distance of 90 ft. from the tower, and has a passage running through its centre, with the keepers' rooms opening from it. These rooms are 16 ft. by 14 ft., and 10 ft. high in the clear. There is thorough ventilation under all the floors and over the ceilings. The roof is boarded with 1½ in. tongued and grooved Singapore red wood, felted, tarred, and covered in with corrugated galvanized iron, supplied by the Messrs. Morewood and Co., of Birmingham. The cast-iron tower was manufactured by the Messrs. Eastons, Amos, and Anderson, of London, whilst the light and lantern were by the Messrs. Chance. There was the usual difficulty in erecting the optical apparatus, as the putty used to secure the prisms in the gun-metal framing had swelled up and bulged all the lining plates to such an extent that the panels could not be got into their places. The lining plates were consequently removed, and the putty, which crumbled to pieces, was brushed out, and replaced by material procured in Shanghai. In ordinary weather the workmen on Sha-wei-shan could see the light of the Tung-sha light-vessel, although distant 20 nautical miles. This light is a catoptric one, by the Messrs. Wilkins & Co., of London.

The new light vessel for Niuchuang has arrived at Shanghai, after a very lengthy passage from London, and on the 9th of July she proceeded north to her station at the mouth of the Liau river.—*The Engineer.*

PROPOSED TUNNEL UNDER THE CLYDE AT GLASGOW.—The enormous extent of the passenger traffic over the Clyde at Glasgow by the harbor ferries, together with the great danger attending the traffic, has led the Works Committee of the Clyde Trust to take action, with the view ultimately of constructing a passenger subway in lieu of the ferry at Clyde street, which is the one that is the most extensively used. Boring operations have been going on for some time at that ferry, with the sanction of the Works Committee. Three test shafts have been made, one on either side of the Clyde, and another within the quay wall. All of them will be put down to a depth of 85 ft., and all the results hitherto obtained are very satisfactory, showing that, so far as the soil is concerned, the construction of a tunnel would not only be practicable, but even easy of accomplishment. Estimates are now being prepared, in order to ascertain the cost of the undertaking, and the revenue likely to be derived therefrom. Several members of the Clyde Trust are quite in favor of the scheme, and there is every probability that before long it will assume a definite and practical shape.

In the month of December, 1864, a lamentable loss of life took place at the ferry already named, owing to the swamping of a ferry boat, which at that time was simply a two-oared boat, capable of carrying 24 passengers; but that number was exceeded on the occasion referred to, on account of a violent and headstrong rush of working-men who were returning home from work. Soon afterwards a small steam ferry-boat was put upon that station; but the fact of nearly 20 persons being drowned at the time naturally led many persons to think of proper preventive measures against such a loss of human life. Amongst the schemes devised there was one which was privately submitted to the harbor authorities by Mr. James Deas, C. E., who was then engineer to the Edinburgh and Glasgow Railway, and had no expectation that he would ever be in the position of engineer to the Clyde Trust, the post which he now occupies. It is the scheme devised by that gentleman which is now brought under the consideration of the Trust.

The following is an outline of the scheme which Mr. Deas submitted along with the plans which he sketched to accompany his letter: He proposed a malleable iron tunnel from 9 to 12 ft. wide by 9 ft. high, the top being 3 ft. or so below the present bottom; the approaches to the tunnel at the two ends to be by means of sloping brick archways or tunnels of a similar width and height. The latter he proposed to carry from the side of the two streets leading to the ferry, a few steps being made at the entrance so as quickly to obtain a sufficient head-room for the brick tunnels under the streets running parallel to the harbor. The entrances could be covered over in a manner similar to the coverings placed over the entrance stairs to the cabins of steamboats. Of course the tunnel would be properly ventilated, and lighted with gas, and a toll might be charged similar to that now exacted

at the ferries. It is believed that the additional safety of such a subway would induce many persons to avail themselves of its use who now never venture into the ferry-boat; and it is not likely that the revenue of the Trust would suffer in the slightest degree.

Such a tunnel would doubtless bring several other advantages. The quay frontage, at present occupied by the ferry stairs on either side of the harbor, would be made available for ordinary quayage purposes, and hence there would be additional revenue from this source. The amenity of the quays would be improved by having them, as at present, subdivided by the ferry stairs; and the traffic on the river would be much facilitated by having the ferry-boats dispensed with.

In the event of the scheme thus outlined, or any modification of it being adopted for execution, we shall take care to inform our readers from time to time of the progress made, and more especially of the means which may be had recourse to for the construction of the tunnel.

Plans for a similar work have also been prepared by Messrs. Story & Smith, Engineers, of West Regent street, Glasgow.—*Engineering.*

The Proposed Canal between the North Sea and the Baltic.—The Berlin correspondent of the "Standard" writes: "A great deal has lately been written about the proposed canal between the North Sea and the Baltic, and both the expense and the importance of the natural obstacles in the way of the realization of the project have been greatly exaggerated. The only elevation which would render a deep cutting or a lock necessary is from $2\frac{1}{8}$ to $3\frac{1}{4}$ German miles in breadth, and not more than $67\frac{1}{2}$ ft. in height, and this can hardly be called a difficulty, as the soil is easily worked. The first estimate, 28,192,000 thalers, may have been too low, and it is known that the Prussian Minister of Commerce from the first contemplated the necessity of employing a much larger sum; but, all things considered, it is highly improbable that 6,000,000 more will be required. The breadth of the canal at the surface of the water is to be 226 ft. and at the bottom 76 ft.; its depth 31 ft. This would afford ample space for four vessels to pass each other, two of which might be large men-of-war. The length of the longest proposed line is 14 German miles, that of the shortest $11\frac{3}{4}$ German miles. The choice of the line to be adopted is the most difficult question that still remains unsettled, as every district in the Elbe Duchies wishes a share in the immediate benefits of the undertaking, and consequently exaggerates the obstacles in the way of other plans, and enhances the advantages of the project most favorable to itself. Besides this, it is desirable to unite, as far as possible, the interests of the merchant shipping with those of the navy. To meet the wishes of both parties it would be necessary to construct various branch canals, which would involve an additional outlay of from 10,000,000 to 15,000,000 thalers. The results of the experience gained in the late war render it almost certain that the port of Kiel will be chosen for the one end of the canal, the mouth of the Elbe for the other. It is highly probable that this and all other questions will now shortly be decided, and the work commenced."—*Building News.*

Poughkeepsie Suspension Bridge.—Eastern exchanges announce that plans have been submitted to the Poughkeepsie Bridge Co., which seem likely to be adopted, for a suspension bridge at that point, to be 130 ft. above the water, and 3,400 ft. in length, with two spans of 1,100 ft., and half spans of 650 each; the towers to be of masonry, and the foundations to be constructed 70 ft. below the surface of the water. The cables to be of steel or iron, and the carrying capacity $\frac{1}{2}$ a ton to the lineal ft. The whole structure is to cost $2,600,000.

Council Bluffs Bridge.—The "Nonpareil" says that the columns of the Un. Pacific R. Co. bridge over the Missouri at Council Bluffs, are now all down to the rock foundation, and filled with concrete masonry to a point above high-water mark. On the west side of the river 2 piers are completed and ready for the superstructure. The first span, reaching from the stone abutment to the first pier on the west side, is nearly completed, and workmen commenced putting in the second span of the bridge last week. Six months ought to suffice to complete it ready for the passage of trains.

Hoosac Tunnel.—Progress for the month of August, 1871: East end heading 133 ft.; total 9,182 ft. from portal. Central shaft 31 ft. east; total 169 ft. east of shaft. West end heading 130 ft.; total 6,620 ft. from portal. Brick arch $27\frac{1}{2}$ ft.; total $183\frac{1}{2}$ ft. from portal.

The work of widening the Boston and Albany Railroad bridge at Springfield is nearly completed. —*Am. Railway Times.*

ORDNANCE AND NAVAL NOTES.

A British Naval Bull Dog.—The iron gunboat Scourge was floated out of No. 4 dock at Chatham Dockyard on Monday, August 26, to be taken down the river to have a trial of her machinery after the cleansing of her bottom. She was taken from Sheerness Harbor on Wednesday to the measured mile at the Maplin Sands, for a trial of her speed, when the mean of 6 runs at full boiler power was 8 545 knots. The Scourge is sister vessel to the Snake. They are gunboats of a peculiar class—small, but formidable—and might not inaptly be termed "the bull-dogs of the fleet." Each vessel is divided into 6 compartments, the foremost of which is allotted to the crew, the next being taken up by the gun and platform. The gun is the new pattern 18-ton, mounted on an iron carriage, which can be lowered into the vessel by a small engine—an operation which can be performed in the short space of 3 minutes, notwithstanding the great weight of the gun carriage and platform, nearly 27 tons. The engine for raising and lowering the gun is situated in No. 3 compartment, and works the capstan on the deck above. On each side of No. 3 compartment is a commodious cabin, on one side for the engineer, and on the other for the gunner. No. 4 compartment is taken up by the boilers and coal bunkers. In No. 5 compartment are the engines, which, although nominally of 28 horses, can be worked up to nearly nine times that power. The after, or No. 6 compartment, is appropriated to the chief officer. The vessel has only one small mast, for signal purposes. She will require a crew of about 18 officers and men, will be able to steam over $8\frac{1}{2}$ knots per hour, can throw a pro-

jectile of 400 lbs. weight a distance of 3,000 yards, at which distance she is almost too small to be seen, and she will draw but little over 6 ft. of water when fully equipped. She has returned to Chatham to complete her fittings.—*Army and Navy Gazette.*

THE NAVY OF ENGLAND —The navy of England is reduced to a state which would be ridiculous if it were not serious. We want at present two vice-admirals—one for the China command and the other for the Channel Squadron; and as it would be worse than useless to blind ourselves to the truth, we are bound to confess that we have no such officers at our disposal unless we re-employed the Hon. G. F. Hastings, or cause a survey to be made on the Hon. James Drummond. Here we are boasting that we are the first maritime power in the world, and we have not two spare vice-admirals. We have fortunately a goodly supply of rear-admirals, but if there is any truth in the rumors prevalent at the clubs, Mr. Goschen is about to commit a grave error. The officer who who is said to be nominated to succeed Sir Henry Kellett is "an excellent creature," but probably the last man on the whole list who should be sent out to occupy a post requiring not only intelligence, but decision and firmness on the part of the individual who may be called upon to fill it. The officer in question has many estimable qualities, but does he possess those which would constitute the able and dashing commander? Then, again, report is busy again with the name of another rear-admiral in connection with the command of the Channel Squadron. Not one word can be said againt his fitness to succeed Vice-Admiral Wellesley, but his appointment would be regarded as a slur on the professional attainments of all the other officers of his rank who have not hitherto been employed, but we fear there is no other alternative. We are perfectly aware of the difficulties which Mr. Goschen has to contend with in distributing his patronage, but in the interests of the country and service we must speak out.—*Army and Navy Gazette.*

A NEW MITRAILLEUSE.—A new mitrailleuse was recently tried at the Camp of San Maurizio at Turin. This new weapon was proposed to the Minister of War, of Italy, by Capt. Mussini, of Florence. A commission of superior officers presided over the experiments. The piece was worked by Capt. Mussini, assisted by the engineer, and the Chief of the Works where the mitrailleuse was manufactured. The principle is like that of Montigny's system, but with great improvements which make it a very practical and effective arm; much is due to the great precision attained in the execution of all its parts, carried to a surprising degree of perfection; the deviation of all the parts of the mitrailleuse nowhere exceeds $\frac{8}{100}$ths of a millimetre, and $\frac{4}{100}$ths of a millimetre in the cartridges. This mitrailleuse has been constructed at the works of Mr. Sigl, of Vienna, the only engineer who has hitherto succeeded in distributing with such precision the openings, so as to fix, without any sensible deviation, the 37 barrels distributed equidistantly in one single circular pile. Each volley lasted 2 min., firing 635 times in each minute, viz., 10 3-5 shots per second.

The experiments were made at the following ranges, each occupying about 2 hours—viz., at 400, 700, 1,000, 1,500, and 1,600 paces; corresponding to 303.36, 530.88, 834.24, 1137.60, and 1213.44 metres. The results of each volley were graphically taken, and were obviously very destructive. The target was formed of a board $2\frac{1}{2}$ centimetres thick, 3 metres high, and 30 wide, normal, and central to the line of firing; at intervals of 25 metres in rear of the first target there were placed others parallel to it, and arranged in such a manner as to represent a battalion formed in columns of companies; so that the shots which passed through or over the first target would strike the second, and so on successively. Of course the number of hits decreased from the first to the last target when the mitrailleuse was properly trained, but increased when the training was high. The proportion of effective hits is represented in the order of the distances we have given by the following numbers—$95\frac{1}{2}$, $79\frac{1}{2}$, $65\frac{1}{2}$, $31\frac{1}{2}$, 27; which shows that even at the least favorable distance of 1,600 paces, 1213.44 metres or 1,327 yards, each of the 4 companies of a battalion formed in column would receive at least $\frac{1}{4}$ of the shots—that is, that not one ball is ineffective on columns of companies. Supposing that the 1,600 paces can be run in 8 min., at "the double;" that the mitrailleuse would fire more than 5,000 shots during that time; and that the battalion is composed of 600 men, each man, on an average, would have to run the gauntlet of 9 projectiles, and that, as we have said, upon the most favorable hypothesis.

The cartridges proved also to be very excellent manufacture, only $2\frac{1}{2}$ per 1,000, *i. e.*, 1 in every 400, missed fire. There were no *contretemps* of any kind, and a member of the Commission expressed his opinion that humane considerations alone would dictate the rejection of this mitrailleuse on account of its terrible effects.—*Mechanics' Magazine.*

BRITISH IRON-CLADS BUILDING.—The following iron and armor-plated men-of-war are at the present time under construction for the Government in Her Majesty's Dockyards and by contract: The Fury, armor-plated turret ship, 4 guns, 5,030 tons and 1,000 H.P. engines, building at Pembroke; the Blonde, iron steam frigate cased with wood, 26 guns, 4,039 tons, 1,000 H.P. engines, building at Portsmouth; the Thunderer, armor-plated turret ship, of 4 guns, 4,406 tons, and 800 H.P. engines, building at Pembroke; the Rupert, iron-clad, ram, 4 guns, 3,159 tons, engines of 700 H P., building at Chatham; the Gorgon, double screw, iron, armor-plated turret ship, 4 guns, 2,107 tons, and 250 H.P. engines, building at Jarrow-on-Tyne; the Raleigh, iron frigate sheathed with wood, 22 guns, 3,210 tons, and 800 H.P. engines, building at Chatham Dockyard; the Hecate and Hydra, double screw, iron, armor-plated turret ships, of 4 guns, 2,107 tons, and engines of 250 H.P. each, building at Poplar and Glasgow; the Frolic, Kestrel, Ready, and Rifleman double screw composite gun vessels, of 4 guns, 462 tons, and 100 H.P. engines each, building at Chatham.—*Nautical Gazette.*

THE HARVEY TORPEDO.—The crew of such ships as happened to be in the Yarmouth Roads recently, either under sail or at anchor, were considerably astonished by their vessels being made the subject of attack by a small steamer armed with one of Captain Harvey's sea torpedoes. The results were, of course, harmless, as the torpedo was not charged, although it was fitted with the

exploding apparatus. The object of the excursion was to test the capability of the crew of an ordinary merchant vessel to manœuvre the torpedo, and further to test the towing gear, and the certainty of action of the weapon when in use. A small paddle-wheel steamer, the Andrew Wodehouse, of the ordinary class, and of about 60 tons burthen, was engaged upon the occasion. The master and crew of the vessel worked the torpedo under the personal direction of Captain Harvey. The torpedo was one of a large number now being manufactured by the London Ordnance Works. It measured 3 ft. 8 in. in length, by 1 ft. 6. in. in depth, and 5 in. in breadth, weighing, when charged, about 1⅓ cwt; on the present occasion, water was used to bring it to the service weight. The slings and buoy rope were of hemp, the towing rope being of ¼ in. diameter iron wire, controlled by a small iron brake, acting on the side of the drum on which the rope was coiled. As a temporary towing-yard, a spar was rigged across the quarter-davits of the steamer on the port side, a leading block being lashed on for the tow rope to reeve through.

Thus equipped, the Andrew Wodehouse started on her cruise, towing the torpedo well out from her side at an angle of 45 deg., with from 20 to 50 fathoms of tow line. The cutwater of the torpedo was at all times sufficiently visible to those on board the vessel to permit its steadiness and uprightness to be observed. The first attack was made against a brig coming on under full sail. The brig yawed, but the torpedo was successfully dipped under her keel with about 30 fathoms of line out. The second attack was against a brig at anchor, with 30 fathoms of tow line out. The torpedo was again successfully dipped under her bottom, both the firing levers being driven home, piercing the detonating capsule. Succeeding attacks were made with similar and invariable success upon other vessels both under sail and at anchor, the torpedo being well manœuvred, and always planted effectually against the object of attack. The final experiment was made with the steamer running at the highest possible speed, in order to test the strength and reliability of all the towing gear. It was also desired to know how much of the wire rope could be effectually veered out from the temporary towing spar, which was about 15 ft. above the water. The steamer attained a speed of 11 knots, and the torpedo was well out from her side at 45 deg, with 50 fathoms of tow line. Only a very few minutes were occupied in each attack, the time of striking being but a few seconds. The experiments were satisfactory, and went to show that if necessary our steam mercantile marine could, with little delay, and at a comparatively small cost, be transformed into a highly efficient offensive power. Although the enemy's guns, if ready, might be brought to bear on the torpedo craft, the latter has chances of escaping, as was proved by the experiments with the Camel tug against the Royal Sovereign, which took place at Spithead some months since.—*Engineering.*

Mode of Discharging Artillery.—Henry Bessemer, of homogeneous steel celebrity, is still "pegging away" at inventions some of which are in a quite different field from those that have brought him fame and fortune. Among the most recent of these is a novel method of discharging artillery. In this a vibrating pendulum is employed, which, falling from one support to the another, makes an electric contact with a fusee to fire the gun. In order to ascertain the distance of an object aimed at, an instrument is employed consisting of a telescope with an arm at right angles to its axis; in front of the lower half of the object-glass is a mirror inclined at an angle of 45 deg. to the axis; at the other end of the arm is another similar mirror, the inclination of which is adjustable and capable of accurate measurement. The instrument is directed at the object the distance of which is required, the upper part of which will then be seen directly and the lower part after two reflections. The movable mirror is then adjusted so that the two parts of the image of the object piece up accurately the one with the other. The scale in connection with the mirror will then indicate the distance in yards or other units.—*Am. Artisan.*

A German Naval Invention.—The "Bromberger Zeitung," in a letter from Dantzic, gives some particulars regarding a curious and interesting addition to the German fleet. Three boats are just now in course of construction in Devrient's dockyard, the destination of which is to place torpedoes under, and thus destroy an enemy's ships. These boats are built almost entirely of iron, and, being about 60 ft. long and only 6 or 7 ft. broad, they have nearly the form of a fish. The deck is not flat, but round, so as to be but little exposed to damage from an enemy's shot. While employed in active operations no one will be visible on board. Contrary to the usual system, these boats will be steered from the bows; and on the deck, above the rudder, there is a slight elevation to allow the steersman to stand on his feet, and a small opening about an inch wide to serve him as a look-out. As they are intended to operate close to an enemy's vessels the armor will be as thick as is consistent with high speed. The most curious part of the invention, perhaps, is that the tiny screw streamers, or barcassen (long boats), as they are called, use petroleum as fuel, which is contained in a number of iron receptacles in the stern, of sufficient thickness to be impervious to projectiles. The chimney is so small that it can scarcely in any case be hit. A narrow gallery, about a foot broad, and enclosed by an iron chain, runs round the boat. The machines have all been furnished by Stöckel and Wagenknecht, so that the boats have been produced in Dantzic from stem to stern. The hold for the torpedoes is in the middle of the boat, as well as the quarters of the crews. One of the barcassen has already been launched, and is only waiting for her engine. The two others are still on the stocks. A liliputian steamer has also been constructed in the same dockyard, in which the inspector of the harbor works will be able to go on his rounds with great rapidity. The whole thing is not larger than an average-sized rowing-boat; it has no deck, and in the middle is the miniature steam machine, which is no more than 2 ft. in diameter, and requires but little attention.

Breech-Loading Ordnance of the Middle Ages.—On Monday last a most interesting consignment arrived at the Royal Arsenal, Woolwich. It consisted of 3 bronze guns, manufactured evidently at an exceedingly early date, although in a most perfect state of preservation as regarded the various parts, and which were forwarded from Portsmouth by Admiral Milne, to whom they had been sent in transit from Rhodes

by Her Britannic Majesty's consul. We understand that a considerable amount of correspondence has taken place with reference to these and some other guns of a like nature, which were accidentally discovered by a diver at the bottom of the sea near Rhodes, and were at the time being sold for the sake of the metal which was contained in them, with a view of melting them down. Fortunately, however, this was arrested in time. These curious specimens of warlike constructive art are supposed to belong to a period anterior even to the date of the battle of Crecy, when guns are said to have been first used. But the great interest which attaches to them is contained in the fact that 2 of the number are breech-loading pieces of ordnance. These are about 5 ft. in length, and would contain a ball from 4 to 5 lbs. weight. At the breech end is a chamber, sufficiently wide and deep to contain a large vent-piece, which can be lifted in and out by means of a handle. This vent-piece is not solid as in the Armstrong gun, but has a space hollowed out within it evidently intended to hold the cartridge. Whether the ball formed part of the cartridge with the powder, or was rammed in afterwards at the muzzle, cannot be ascertained, but as the calibre of the barrel is greater than that of the chamber, it would appear that the latter surmise is correct. A plug passing through the breech of the gun, and through the solid end of the vent-piece, kept the latter in its place when the charge was fired, but there is an orifice in the cascable of each of the guns which may have contained a breech screw. But the material is so much eaten away that it would not be possible to determine whether there had been a thread upon the orifices or not. The vent-hole is at the side of the vent-piece handle, and so contrived as to be exactly upright when the plug is in its place. On the trunnion piece of one of the guns is the figure of a lion with wings. In a similar position on the other is a human figure apparently holding a book. But the carving is so nearly obliterated that it is difficult to distinguish whether these images are human or otherwise. Such was the breech-loader of probably the 14th or 15th century. Perhaps one of these days we shall be digging up the portable field telegraph which was used by Pharaoh in keeping up a communication with his base of operations when pursuing the Israelites! The third gun, which was received yesterday, is an ordinary-looking weapon, somewhat similar in shape to those which were used in the last century. It has a bore $3\frac{5}{8}$ in., measures about 9 ft. in length, and is also of bronze, but does not bear the same stamp of antiquity as the rest.—*Engineer.*

NEW BOOKS.

Hand-Book of British Fungi. By M. C. Cooke, M.A. London: Macmillan. For sale by Van Nostrand.

This long expected work, by one of our most industrious mycologists, has at last made its appearance. It contains descriptions of all known species of British Fungi, amounting to the enormour number of 2,809.

Each genus is illustrated by a carefully executed wood-cut. The student is aided in the discrimination of the genera *Agaricini*, by a series of colored tables.

The thanks of every lover of botanical science are due to the author for his valuable work, which, though of necessity a compilation, is not wanting in original matter.—*Quarterly Journal of Science.*

Elementary Treatise on Natural Philosophy. By A. Privat Deschanel. Translated by Professor J. D. Everett. Part II. For sale by Van Nostrand.

The second part of this beautiful treatise fully maintains the character exhibited by Part I., of which we gave an account some time ago. It is understood that the book is now half completed. The present part is occupied entirely with the consideration of Heat.

The present editor has added some valuable matter to the original edition.

When complete the work will be one of the most beautifully executed, as well as most satisfactory books on General Physics in the English language.

The Theory of Strains. By John H. Diedrichs, C. E. Baltimore: Smith & Trowe. For sale by Van Nostrand.

This is a complete compendium, for the calculation and construction of bridges, roofs, cranes, etc.

The methods employed in calculation are those of Ritter in his "Dach und Brucken Construction," with which our readers have been made somewhat familiar through the recent translated articles in our pages. Indeed both illustration and text will look familiar to those who have studied Ritter.

The different leading forms of trusses are discussed in logical order, and the method may be readily followed by young engineers not yet familiar with higher analysis.

Physical Geology. By Ralph Tate. London: Lockwood & Co. For sale by Van Nostrand.

This is a new addition to the well known Weale Series. It presents in a brief way, and good style, a discussion of the physical causes which have produced geological changes.

A separate treatise is to follow, devoted to Historical Geology.

The illustrations of the present work are numerous and good, and altogether the work presents the best brief compend of Geology that we have seen.

Manual of Mining Tools. By Wm. Morgans. London: Lockwood & Co. For sale by Van Nostrand.

Besides the necessary descriptions of the various tools, this little work also comprises observations on the materials from and processes by which they are manufactured; their special uses, applications, qualities, and efficiency.

A fine atlas, containing 235 wood engravings of mining tools drawn to scale, accompanies the text.

The introductory chapter is quite a complete treatise on steel, and the various processes by which it is produced.

The Workman's Manual of Engineering Drawing. By John Maxton. London: Lockwood & Co., Stationers' Hall Court, 1871.

This is a very useful little work for mechanics, or those who have yet to acquire the various "notions" necessary to mechanical drawing, and

it is consequently designed principally for the use of the "working engineer," who it is presumed has not had the advantage of instruction in the drawing office. Although the description of instruments and pencils there recommended, together with some of the minor operations respecting preparing the paper for drawing upon, are not such as we should prefer, it is evident that the treatise is written by a thoroughly practical man, and perhaps the very details to which we object might be of service to those who know no better. The instructions for setting out work, so far as they go, appear to be correct, but we could have wished to have seen in a work professing to instruct engineers a few more engineering examples for their imitation.

Mathematical Instruments: their Construction, Adjustment, Testing, and Use. New edition, Vol. I. Drawing and Measuring Instruments. By J. F. Heather, M. A., late of R. M. A. London: Lockwood & Co. 1871. For sale by Van Nostrand.

This book was published in 1849, and since then has been used in Government Military and Naval Schools—forming also, by authority, part of a Midshipman's Kit

This tenth edition has been entirely rewritten for the purpose of describing the latest improvements; the subjects have also been separated into three portions, the second volume being devoted to Optical Instruments, and the third to those used in Surveying and Astronomical Observation. These changes are judiciously made; and we need say nothing concerning the well-known merits of so useful a book.—*Mechanics' Magazine.*

A Rudimentary Treatise on Analytical Geometry and Conic Sections. By James Hann. New edition, Rewritten and Enlarged. By J. R. Young. London: Lockwood & Co. 1871. For sale by Van Nostrand.

In this work there is little except the general plan of the original left. Both in method and execution Professor Young's work is a decided improvement on Mr. Hann's, while it retains the important feature of cheapness, through which, in presenting sound mathematical works at an almost nominal price, the series of Mr Weale has done such good service to education.—*Mechanics' Magazine.*

MISCELLANEOUS.

American Views on Patent Laws.—The Hon. Charles Mason, late Commissioner of Patents, has written George Haseltine, M.A., chairman of the meeting on the patent laws, reported by us last month, an instructive letter published at length by "Engineering," of which we give a brief abstract:—"I have," he says, "never had any serious doubt of the wisdom of a judicious system of patent laws. The public welfare is best promoted by inspiring individual effort in respect to invention, through the motive of private gain; and who can more justly claim the exclusive use of any property than he who has brought it into being? The American system of examination is productive of much advantage to inventors and the public, but I doubt the wisdom of lodging in officials an unlimited power of rejection. If the action of examiners were advisory and adjuvant, reserving to an applicant the ultimate right to a patent, at his own risk, the chief objection to this system would be removed. The fees by all means should be small—barely sufficient to defray the expenses of the Patent Office. Inventors are benefactors, and as a class are poorly compensated for their labor. The imposition of large fees discourages invention, and thereby checks the progress of civilization. This cannot be sound policy. Experience leads me to the conclusion that patents should be granted for more than 14 years; but this term, in most cases of merit, is extended by our office to 21, and often by Congress to 28 years. The new law limits the term of a patent to 17 years, which will, no doubt, hereafter be extended; and I do not think 21 years too long a period for the original grant. In one respect I like your system better than ours—your fees are paid in instalments, giving the patentee the option of keeping his patent alive. The French plan of annuities is carrying the matter rather too far. I think the English system better than the French or the American, and all that is needed is a reduced rate of fees. Experts are often very useful, but they are regarded with suspicion, and their opinions have little weight in our courts; therefore, what might be a great evil, carries in some measure its own remedy, and the interposition of jurors in patent suits is generally avoided by obtaining injunctions in Chancery, which is our usual remedy for infringements."—*The Globe.*

The Rain-fall of the North and East of Asia.—M. Raulin, M. A. of Sciences, of Paris, proves by the table annexed that the summer rain-fall of the great plain of Central Europe extends beyond the chain of the Ural mountains, very far towards the East, as far as the shores of the Pacific Ocean, where the differences of relative quantities are even more striking. At Nijné-Taguilsk the minimum rain-fall in winter is but little more than $\frac{1}{5}$th of the maximum in summer; and at Nertchinsk is only about $\frac{1}{30}$th part:

	Quantity of Rain-fall.				
	Winter.	Spring.	Summer.	Autumn.	The Year.
Nijné Taguilsk.....	49	85	236	94	464
Tobolsk	61	58	230	102	450
Nertchinsk	9	59	268	126	462
Yaksutsk..........	47	37	85	91	260
Pekin............	13	55	450	89	607
Macao............	84	477	709	450	1720
Saigon...........	1	149	732	711	1593
Yokohama.........	75	191	306	386	1058
Manilla	123	121	866	641	1751

In China, at Manilla, and in Japan the same proportions are found, but at Macao there is a double maximum as yet unexplained (May and September).

Combustion of Metals by M. A. Ditte, M.A. of Sciences of Paris. The numbers obtained by the author explain different physical peculiarities of the metals examined. Thus, magnesium burns

with dazzling brilliancy, the combustion of zinc is energetic, that of Indium difficult, and Cadmium melts and oxidizes with a flame scarcely visible; heat and volatility decrease in the same order. Similar analogies are observed in the reduction of the oxides of the four metals, in the decomposition of steam, etc. The following table shows the striking parallelism of their different physical properties :—

	Magnesium.	Zinc.	Indium.	Cadmium.
Density.......	1.75	7.0	7.15	8.65
Equivalent.....	12	33	35.9	56
Specific heat ..	0.2?33	0.0955	0.088 theory	00.567
Point of fusion.	about 500°	about 400°	....	about 315°
Point of volatilization	" 1100°	1040°	red	860°
Heat of combustion	72,890	44,258	37,502	16,231
Color of the oxides	White	white, light yellow	deep yellow	orange or black.

MINING IN JAPAN.—While the arsenal at Yokoska and the mint at Osaka have been opened with the due amount of ostentation and publicity, the Japanese Government have recently had completed for them a more humble, but nevertheless quite as important an undertaking as either, without its being even heard of. Mr. Gower, mining engineer to the Government, has erected a set of machinery on the island of Sado for crushing and washing the gold quartz, which is found in such abundance there, and it now has been at work for the last few weeks. Sado has been the scene of mining operations for an unknown period, mines being found in different parts of the island, of which no record exists as to when they were worked. Those at present in operation lie on the west side of the island, at a village called Ai-kawa, and here Mr. Gower has erected his machinery. The entrances to the mines are in a valley running up from the village, and they are generally from 150 to 300 ft above the level of the sea, and from 1 to 1½ mile from it. The new machinery has been erected at the foot of this valley, and from the mines a 2-ft. gauge tramway has been partially constructed, which, when completed, will be an immense saving of labor in the conveyance of the quartz. About ¾ of a mile of the tramway is already finished, and it is calculated that a saving over the whole system of $\frac{1}{5}$ the cost of transport has been effected by it. In this valley alone there are hundreds of mines which have been worked at different periods within the last 200 years, 29 of which are at present in operation ; 4,000 miners, crushers, etc., are employed at these, who, with 3,000 fishermen and agricultural laborers, compose the population of the village. The natives, who have been in the habit of crushing the quartz with cast-iron mallets worked by hand, while the grinding washing processes were equally primitive, have succeeded in working 6 to 8 tons of quartz per day, but at a great expense to the Government The new machinery is capable of turning out 18 to 24 tons per day, its working expenses not being more than $75 for that time. The quartz is said to be very rich, having large quantities of gold, silver and copper in it, but extremely hard, and therefore difficult to work. The machinery is erected in a substantial wooden building, and is driven by an engine of about 20 horse power. The whole process of breaking up the rock, converting it into powder, washing the powder so formed, and separating the gold, silver, and copper, is here carried on. And as parts of the machinery are most unwieldy and heavy, too much credit cannot be given to Mr. Gower, who, with the assistance of a single European, has managed to put them all in their places, and to all appearance in perfect working order.—*Japan Mail.*

AMBER.—A very large proportion of the amber appearing in the various markets of the world is supplied by the province of Prussia, including the neighboring district of Memel. The following particulars are gleaned from a report by Mr. Ward, Her Majesty's Vice-Consul at Memel. In the western portion of the province of Prussia amber is found not only on the seashore, but also in the mountainous ranges of the interior ; excepting, however, in rare cases of its appearance in so-called "nests," amber is only to be met with in isolated pieces in the latter localities, so that the profit arising from the amber diggings among the hills is but a very moderate one, and may be estimated at about double the amount paid by the proprietors for the wages of the diggers. In East Prussia, however, and especially in that part called the Samland, amber is more abundant, and during the prevalence of certain winds is frequently thrown upon the shore by the sea in large quantities ; it is collected there, as well as fished for in the surf ; it is also dug out of the sand hillocks running along the seacoast. In these sand hillocks regular beds of amber are found enclosed in a soil of blue clay, which is to be met with at an average depth of about 100 ft. in a thickness of 25 to 30 ft. It is stated that out of some diggings established in those parts 4,500 lbs. of amber were raised in the course of 4 months of the year 1869. Diggings of this kind exist at present in various spots of the Samland. There are establishments at Brusterort, where amber is obtained by divers from the bottom of the sea, and at Schwarzort, near Memel, where it is raised by dredging for it at the bottom of the Curish Haff. The importance and size of the dredging establishment last mentioned has of late years increased considerably, and at present about 80,000 lbs. of amber are annually obtained by it. The total amount of amber obtained during the year 1869 in all parts of the province of Prussia by the various means of collection is estimated at about 150,000 lbs., the value of which may be taken at 550,000 Prussian dollars. The quantity collected (by fishing for it) in the sea and upon the shore is about equal to that raised by the digging and dredging works. According to the opinion of competent persons, the produce of the diggings could be increased considerably by working them upon a regular mining system. Apart from the fact that no certain knowledge has hitherto been arrived at as to the actual extent of the amber fields in the blue clay,—and these fields exist most probably not only in the vicinity of the seacoast, but also in the interior of the Samland, and even beyond that district and the frontiers of Eastern Prussia,—it is most likely that below the stratum of clay to which the diggings are at present confined there are other strata in which amber would be met with. This supposition is based upon the circumstance that considerable quantities of amber have been found among the soil washed

away by the sea during heavy gales from those portions of the coastal sandhills which lie below the layer of blue clay first alluded to. The prices of the principal kinds of amber, as stated by an official report, vary according to the size, ranging from 22 Prussian dollars per lb., where the pieces run about 9 to the lb., to $1, where the lb. requires 100 pieces or more. The prices of larger (so-called cabinet) pieces are subject to great fluctuations, and are fixed by the increase or decrease of demand from the East; the prices of the commoner kinds seldom vary more than about 10 per cent. The chief seat of the retail amber trade is Dantzic; the wholesale trade is at present in the hands of only 2 or 3 firms in the province of Prussia. The working of the Prussian amber into mouthpieces, beads, etc., is likewise carried on chiefly at Dantzic, but also in all large cities; of late a manufactory of amber wares has been established at Polangen, a small Russian town near Memel, and it is intended to open similar works at Konigsberg, Moscow, and at New York.—*Mining Journal.*

The Utilization of Waste Material in Mining.—Immense heaps of refuse or "tailings," as they are technically termed, accumulate where mining operations are carried. These contain a good deal of metal, but no way has yet been devised of extracting it economically. We have improved upon the ancients in that respect, and posterity may improve upon us, as is suggested in the following extract from an Australian journal:—

"In the year 4000, or thereabouts, when the Anglo-Australian race shall have been 'played out' on this continent, and our posterity shall have degenerated as the Greeks have done, will the New Zealander of the period, accomplished in arts which are unknown to us, and armed with scientific appliances such as we have never dreamed of, come over to Victoria and extract tons of gold from the tailings in our desolate and deserted gold fields? The question is suggested by what is actually taking place in Attica. About 300 years before the Christian Era, the silver mines of Laurium were exhausted and abandoned; but 7 years ago a Franco-Italian Company obtained a concession to treat the scoria and other refuse for silver, and their operations have been conducted on so large a scale that a town containing 4,000 inhabitants has sprung up on what was formerly a solitude; a railway has been constructed to the nearest port, and a small steam vessel plies twice a week between Argosteria and the Piræus for the transport of the argentiferous tailings to the roasting furnaces."

Novel Surface Condenser.—We see in an account of a British manufacturing establishment an account of a surface condenser of somewhat notable character.

It is an evoparative surface condenser, in which the condensation of the steam is mainly effected by means of surfaces supplied with a thin stream of water, the actual evaporation of which—and not merely its rise of temperature—effects the condensation of the steam. The steam is exhausted into a narrow annular chamber, or the internal intermediate space between two concentric cylinders, water in thin streams being made to flow down both the outer and the internal surfaces of the annular chamber. Each unit, shown in the sketch of the condenser, thus consists of a pair of thin cast-iron cylinders, the smaller one within the other, leaving such a narrow annular space that the steam offers a considerable surface for its condensation. The joint at the bottom is formed by an annular trough cast on a plate with a central hole, and with lead run in. At the upper end, on the outer cylinder, is cast an internal fillet, fitted against the outer surface of the inner cylinder, and a space is left between the joints for a little water to prevent leakage. An annular trough, open at its bottom, rests on the tops of the cylinders on small ribs connecting its sides. Down the narrow annular spaces water from the pipes above runs in a thin film over both the internal surface of the inner and the external surface of the outer cylinder. The steam to be condensed enters the pipe at the side, and into the annular space, and the water of condensation is exhausted out below by the air-pump. The condensing action of an upward current of air also comes into play, as the condenser is carried by standards so far apart as to leave free access to the inflow up the centre of the annular casing. A number of pairs—four or more—of such units are thus arranged in a row, and constitute a very useful condenser for an ironworks—taking up some room, but, on the other hand, requiring a comparatively smaller quantity of cold water. Several of these condensers are in use at Middlesbrough, England, and have also been adopted for the Lambeth Water-works.—*American Railway Times.*

Amongst the papers recently read before the Hanoverian Architects and Engineers' Association, and published in the "Zeitschrift des Architecten und Ingenieur-Vereins zu Hannover," vol. xvii, No. 1, we find, at p. 15, one by Professor Ruhlmann, of Hanover, on the history of military breech-loaders, the origin of which he places as far back as the second half of the 15th century. He compares the Prussian needle-gun with the Chassepot, both as regards the weight and dimensions of the arms and the ammunition which they carry, and concludes by recommending the Martini-Henry rifle (already adopted by the Swiss Government) as the best military rifle yet devised.

Self-Acting Rudder.—At the International Exhibition of Naples, a drawing of a self-acting rudder, proposed by Signor M. Siciliano, of Palermo, was exhibited, and attracted great attention as a useful application of electro-magnets. In fact, in the apparatus as described, the movements of the rudder would be entirely controlled by the compass; any deviation in the latter gives a corresponding motion to the rudder which continues until the compass returns to its due position.—*Mechanics' Magazine.*

Burlington, Vt., can boast of the largest planing mill in the world. The lumber yards, docks, sheds, mills, etc., of the firm, cover an area of 50 acres, and in this area there are about 7 miles of plank road. To carry on this establishment from 400 to 500 men and boys are employed.

Coal has been discovered in Rajpore and Kummun, in the territories of the Nizam. Miners have been sent to ascertain the extent of the seam.

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THE METRIC SYSTEM.

II.

OBJECTIONS TO THE METRIC SYSTEM CONSIDERED.

In all that I have hitherto said, I have not dwelt one moment upon the intrinsic merits of the metric system itself. I have not thought that necessary. I am addressing intelligent men who know the system, and who know that, for the whole circle of our dealings with quantities, it stands, for easiness of apprehension, for convenience of use, and for the degree to which it facilitates reductions, precisely where our federal currency stands, among systems of money. The simplicity of the relations, moreover, by which it connects the measures of surface, of capacity, and of weight, with the linear base, is such as is nowhere else found; and such as to make of the system a powerful intellectual machine, and an educational instrumentality of inappreciable value. All this I pass by. But I cannot pass so lightly by the objections which have been urged against the system, and of which, in my view the importance has been, in most instances, exaggerated beyond all reason; since, through the wide circulation of the report of your committee on this subject, the high authority of this learned convocation has been made liable to be popularly regarded as attesting their gravty. Consistent with the duty imposed upon me on this occasion, therefore, I cannot pass them by; although the extent to which I have already trespassed upon your indulgence forbids that I should examine them with all the fulness that I could desire.

We are told, then, first, that the linear unit of the system is too large. Too large for what? Too large in the words of your Committee, "to be apprehended by a young and uninstructed mind." This is something which I confess that *I* do not apprehend. A metre, I suppose, can be brought into the school-room; and can be seen without difficulty, even by a very small boy, from end to end. I remember, when I was a very small boy myself, seeing something brought in which was about as long as a metre; and if I did not apprehend it at the time, I was at least very apprehensive of it.

But Mr. Adams says the metre is too long for a pocket rule. "Perhaps," he remarks, "for half the occasions which arise in the life of every individual for the use of a linear measure, the instrument to suit his purposes, must be portable, and fit to be carried in his pocket. Neither the metre, the half-metre, nor the decimetre is suited to that purpose." What then would Mr. Adams have? Would the foot rule fit into a man's pocket more conveniently than the decimetre? Does any man carry a foot rule in his pocket in any other than a folding form? And cannot a folded metre be carried in the pocket as easily as a folded foot? I at least find it so; as this rule proves, which I here present you. But since we have not yet adopted the metre as our unit, and since, after all, in

spite of what Mr. ADAMS says, or anybody else says, it happens to be notorious that a foot is *not* the measure which, "for half the occasions which arise in the life of every individual," is the most useful; the portable measure which we commonly find in men's pockets is a tape measure of a yard or a fathom in length, put up more compactly than is possible for any rule, whether long or short.

As to what *ought* to be the value of the standard length-unit opinions differ. The British standard is a yard. The Russian is the sagene, more than twice as long. Capt. PIAZZI SMYTH almost fanatically attaches himself to the inch, a measure which he believes with implicit faith to have been divinely given to CHEOPS, builder of the great pyramid, and again to MOSES in the wilderness; and in what he, no doubt, regards as the great work of his life, he uses no other to express the largest dimensions.

But it is also said that there are things to be measured in the common affairs of life that are less than a metre. I should suppose so. There are likewise many things to be measured less than a foot, or an inch. They measure these things in England even though the yard is their legal standard. In mechanical engineering, in France, the centimetre is the unit; in physics the millimetre. It does not unfit them for these uses, that their names happen at the same time to be expressive of relation to the standard. The metric unit of weight in commerce is the kilogramme; in analytic chemistry and pharmacy it is the gramme. The metric unit for dry measure is the hectolitre; for liquid measure, it is the litre; the metric agrarian unit is the hectare; the metric itinerary unit is the kilometre. It is in fact one of the merits of the system, that while, like all other systems, it allows any denomination to be made a unit measure for special purposes, yet it allows instantaneous transformations from one denomination to another without changing a figure, but by the simple removal of a point. This cannot be done in non-decimal systems. The inch, for example, is with us the unit of the mechanical engineer and the draftsman. The rod is the farmer's unit of distance. But to reduce inches to feet you must divide by twelve, changing all your figures; and to reduce rods to feet you must multiply by sixteen and a half. This plan does not seem to me preferable to the metric. When your committee say that in their opinion "other units besides the base-unit should be used, as secondary bases for collections of numbers," I agree with them. It is what, in the employment of the metric system, I have always been in the habit of doing myself. But if, when they say this, they mean to say that values expressed in units of these secondary bases ought *not* to be transformable by the simplest processes possible into units of the standard base, my impression is that they will fail to carry the world along with them.

Another serious difficulty is started, of an educational character. Ten, it seems, is a difficult number to grasp, and one-tenth part is a still more difficult fraction. We can never know anything about one-tenth, "until we have divided the unit into two equal parts, into three, into four, and so on up to ten." Since this is the case, it is melancholy to reflect how much more objectionable is our actual system of weights and measures than the metric; since it will be necessary to divide the foot into two equal parts, into three, into four, and so on all the way up even to twelve, before the faintest conception of an inch can begin to dawn upon our minds; and when we turn our attention to the pound and the ounce avoirdupois, the formidably protracted extent of this unavoidable operation becomes quite disheartening. Still, however grave this business of ten may be, I suppose that our children must some time or other know something about decimal arithmetic; and they will have to know something about it whether they learn the metric system or not. If they know it, they know the system, all but its nomenclature; if they don't know it, then I can conceive no educational machinery better suited to make them know it than the visible magnitudes of the metric measures placed before their eyes. The question is not whether we shall teach the metric system to babes; but whether we shall teach it along with the arithmetic, and as a part of the arithmetic, which boys must learn at any rate. The objector does not apparently discover that his argument is no less damnatory to our Federal currency than to the metric system; yet my observation in the streets of New York satisfies me that gamins of very tender years, without having enjoyed the

advantage of scholastic culture or having been carefully and systematically carried through the mental operation of dividing the unit into two parts, into three parts, into four parts, and so on up to ten, acquire an acute appreciation of the relative value of a dime stamp and a nickel.

It is objected again that while the decimal ratio is infinitely more favorable to calculation than any other, yet for sensible objects, and for the daily purposes of life, the binary subdivision is to be preferred. If so, then let us use the binary so far as convenience may demand. There is no need on this account to reject the decimal, which for purposes of calculation is of priceless value. No harm is going to arise from employing both. We divide the dollar certainly into halves and quarters, to our great convenience ; and the decimal system of the Federal currency is none the worse for that. We used to divide it into eighths and sixteenths even ; and Mr. ADAMS says that, if the Spanish mint had not furnished us with coins representative of these values, we should have been obliged to coin them themselves. Yet within ten years after Mr. ADAMS wrote, we had effectually swept ou all this fry of foreign coinage, and nobody now perceives the want of it. Again, the Swiss pound is half a kilogramme. Take half any number of Swiss pounds and you have kilogrammes. Double the number of kilogrammes and you have Swiss pounds. The Swiss, moreover, use both the decimal and the binary subdivision. I presume they would not do this if they did not find it for some purposes useful, as we do in our Federal currency. The Swedes, some fifteen years ago, introduced the decimal subdivision, but they still retain some binary relations. Some such binary relations are recognized also by the French law; but it does not therefore follow, as your committee infer, that this fact "must give rise to much confusion." Neither is it true, as they also maintain, that we cannot adopt the essentials of this system without " adopting it as a whole and excluding every other:" by which I understand them to mean that we shall not even adopt metric values for our units, as Denmark has done, and as Austria has done, and as Turkey has done to a certain extent, without adopting the nomenclature throughout, and sternly prohibiting the use of all binary division; or that we shall not adopt if we please the decimal relations as Sweden has done, without adopting either metric values or the nomenclature; nor adopt the metric values and the decimal system complete, and yet reject the nomenclature, as Holland continued to do for half a century, and has only ceased to do within the last two years. Surely, things that other people have done, we may do ; nor is there going to be, as your committee apprehend, any " fierce conflict" about the matter, nor any need to talk about " the spirit of a free people," or to insist on the fact that Americans are not habituated to "blind obedience to imperial edicts."

Can it not be understood that nobody of the great party who are seeking metrological reform and perfect international accord on this important subject, is bigotedly devoted to the metric system for its own sake ; or resolutely determined to yield nothing that is in it, or to accept nothing that is not in it, on any consideration whatever? Their battle is for a *common* system, be that what it may ; but if they believe that that common system will be found at last to embrace the main features of the metric system, they are not to be told that they shall have nothing else, if anything else superadded to it will make it either theoretically or practically any better. Mr. ADAMS wrote fifty years ago. What he wrote seems to have impressed your committee much more forcibly than all that has happened since. But the world has moved since the time of Mr. ADAMS, and it is perhaps not quite in order to tell us that if we think it a good thing to divide by ten, we shall never be permitted to divide by any other number so long we live. The first great point to be secured is commensurability of unit bases. That point once gained, the battle is substantially over. As for nomenclature and subdivisions, however important these matters may be, their importance is secondary, and they may be attended to afterwards.

Sweeping propositions are rarely wholly true. It is not a fact that binary subdivisions of weight and measure are always necessarily the best. In small dealings, the convenience of buyers and sellers is best consulted, when the multiples and submultiples of quantities correspond with

the multiples and submultiples of coins. If a pound of any commodity costs twenty-five cents, it would suit all parties who use the Federal currency better if we could divide the pound evenly into five parts, than it does now to divide it into four. Nothing is more certain than that quantities bought and sold, and the instrument of purchase and sale, should be subject to the same law.

But, as just remarked, the first point and the great point to be secured, is commensurability of unit bases. This can be accomplished if we please, with great facility. Our foot differs from three decimetres by a very inconsiderable fraction—less than two-tenths of an inch. If we make this slight change in the length of our foot, we are in harmony with nearly all of continental Europe. As for the other measures, they present no difficulty when the measure of length is once adjusted; for measures of length determine the dimensions of permanent constructions, while pounds and gallons are for ascertaining quantities of substances usually perishable. Men are disposed therefore to adhere with more obstinacy to their measures of length than to those either of weight or of volume. Mr. ADAMS's report shows that, in the past history of England, nothing has been more unstable than the value of the pound, the bushel and the gallon. There was a time when the gallon of liquid capacity contained only 216 cubic inches—in one sense a judiciously chosen value, since it was just one-eighth part of a cubic foot. The dry measure gallon contained, at the same time, 264.34 cu. in., corresponding to a bushel of 2,114.68 cu. in. And there was a ratio connecting the liquid and dry measures, which was that of the specific gravities of wheat and Gascon wine. Mr. ADAMS is quite enamored with this duplicity, which extended to the weights as well, between which the ratio has been pretty closely preserved down to our time. But this liquid gallon went on, as Mr. ADAMS explains, to be successively 217.6 cu. in., 219.43 cu. in., 224 cu. in., and finally as with us now 231 cu. in. As to the bushel, it seems to have had all sorts of value. By statute of 1496, passed in the reign of Henry the VII., it seems to have been ordered that this measure should contain 1792 cu. in.; but this statute was never carried out. There are two exchequer standards of this reign, one of 2124 cu. in., and one of 2146 cu. in., which latter is called the Winchester bushel. But then, under HENRY VIII., we have the large bushel of 2256 cu. in., from which came the ale gallon of 282 cu. in., so long in use with us. A bushel afterwards appeared of 2148.5 cu. in., and subsequently the Winchester bushel was found to have somehow worked its way up to 2150.42 cu. in.; at which value it was in 1701 made the standard in England, and so became the standard with us, as it continues to be yet. But just four years after Mr. ADAMS so strongly expressed his regrets at the destruction of the "uniformity of proportion" contemplated by the beautiful theory of the British measures, the British Parliament took this whole business in hand. Instead of improving the capital opportunity afforded them of correcting the irregularities which his report signalizes, they quietly struck out of existence every measure of capacity in use, whether wet or dry; and established the system of imperial measures, wherein the bushel contains 2218.1907 cu. in., and the gallon 277.2738 cu. in., to be used equally for commodities of all descriptions. This was a tolerably formidable change and a tolerably sudden change; but it occasioned no insurrection; nor did the people even run after the carriages of the ministers, shouting "give us back our bushel;" as we are told they shouted in 1752, "give us back our eleven days," when the Gregorian was first introduced into England. Changes of metrological systems, then, are possible, and are possible even for us, without provoking "fierce conflicts." All that is necessary is that the people should know what they are, and should feel that they are desirable.

Your committee themselves are not averse to all change. There is one modification of our system of weights which they actually propose to our acceptance. The recommendation is made moreover so impressively, out of sense of "duty plain and imperative," that for one I was prepared for something startling; for at the very least a proposition to do away forever with the perfectly unnecessary Troy pound. I am compelled to confess my disappointment. The proposed innovation so solemnly introduced is explained in the following words: "In analyzing these weights, it is found that the ounce

in the apothecaries' weight and the ounce in the weight Troy are identical, and that each exceeds the ounce avoirdupois by its eighty-three-thousandth part very nearly ; hence, if the ounce Troy, or the apothecaries' ounce, be diminished by its eighty-three-thousandth part, the result will be the ounce avoirdupois, or the one thousandth part of the weight of a cubic foot of distilled water, and then these three weights will have a common unit."

I have pondered this passage profoundly, but I have not been able to see my way to the bottom of it. It has been my lot to be compelled to transform Troy ounces into avoirdupois ounces very frequently ; but I have always found the difference to be 42.5 grains, while it is here apparently hardly six one-thousandths of one grain. Presuming, however, that something may have been intended which is not said, and that, at any rate, it is designed somehow to make the Troy and apothecaries' ounce equal to the avoirdupois ounce, I accept this proposition as a concession so far as it goes to the cause of uniformity and simplicity ; but I ask what justification can exist after abolishing the smaller denominations, which alone are used by the jewellers and dealers in bullion, or even by the druggists (for the wholesale drug trade is carried on in avoirdupois pounds)—what justification can exist after this, for retaining the pound of twelve ounces.

I would point out further that, since the ounce, after being reduced by nearly its eleventh part, is still, according to the proposition of your committee, to consist of four hundred and eighty grains, the grain must accordingly be reduced in the same proportion; so that all the confusion which could arise in pharmacy and the trade in precious metals from changing the grain for the milligramme, whereby something might be gained, will be here introduced without gaining anything at all.

It has been furthermore urged as a fact very injurious to the pretensions of the metric system, that this system has never been permanently applied to the division of the circle, to which, if to anything, it ought to be peculiarly adapted. Those who use this argument ought to remember that the Arabic numerals, the symbols of algebra, and the division of the circle, are three things, (and the only three things, I believe,) which were the same for all civilized mankind, when the metric system was created. To change the law of circular division was to introduce diversity where uniformity prevailed before ; and also to destroy the usefulness of a vast scientific literature which had been founded on the sexagesimal division. Yet the French did make the experiment of dividing the quadrant centesimally, both in tables and in instruments; and what was thought of its convenience by the ablest astronomers and geodesists of that day may be inferred from the following incidental remarks of Delambre, in his description of the operation of measuring the great French meridian arc. "Three of our four circles," he observes, "were divided into decimal grades or degrees, each having the value of $360^{\circ} \div 400 = 0^{\circ}.9 = 540' = 3240''$. This division is much the most convenient for the uses of the repeating circle, and would be equally so for the verniers of all instruments whatever. Many persons hold to the old system by habit, and because they have made no use of the new; but no one of those who have practised both will willingly return to the old."

When the metric system shall be universal, it is probable that the decimal division will be once more applied to the circle. Nothing could be less convenient than the sexagesimal which is now employed. And in point of fact, this law of subdivision has been already abandoned for all values below seconds; such values being now invariably expressed decimally, though, two or three hundred years ago, it was carried to thirds, fourths, and even fifths, as may be seen in any old astronomical work, or in Delambre's *History of the Astronomy of the Middle Ages.* I regard this objection therefore as without foundation.

But it is apparently a very strong point with most objectors to the metric system, that our present measures of length have their representatives—the assumption is that they have their prototypes—in the dimensions of some parts of the human body. Thus, your committee say, the foot "was undoubtedly adopted as a standard of measure from the part of the body from which it takes its name." Some foot was undoubtedly so adopted, but what foot? The Greeks used the foot earliest, and the Olympic foot is said to have been the measure of the foot of Hercules. But there were foot measures in use among

them of several other magnitudes; and while it is difficult to know with certainty what any of them were, compared with ours, it is not difficult at all to ascertain that they differed widely among themselves. Thus the authorities state that the Macedonian foot was 14.08 in., the Olympian 12.14 in., the Pythian 9.72 in., and the Sicilian 8.75 in. Here, in the earliest history of this measure, we have the largest room for choice. In more recent times, the diversity has been greater still. Thus in Italy the foot was, not long ago, 11.62 in., in Rome; 13.68 in. in Lombardy; 23.22 in. in Lucca. In France it was 9.76 in. in Avignon; 9.79 in. in Aix-en-Provence; 10.57 in. in Rouen; 14.05 in. in Bordeaux; while the *Pied du roi*, for France generally, was 12.79 in. In Switzerland, it was 10.52 in. in Neufchatel; 11.33 in. in Rostock; 11.99 in. in Basel, and 19.21 in. in Geneva. In the Spanish Peninsula it was 10.12 in. in Aragon and 10.96 in. in Castile. In Germany it was 9.25 in. in Wesel; 10.89 in. in Bavaria; 10.998 in. in Heidelberg; 11.45 in. in Gottingen; and 13.12 in. in Carlsruhe. In the Netherlands it was 10.86 in. in Brussels, and 11.28 in. in Liege. These examples will suffice, but there are plenty more behind.

It can hardly be supposed that all these measures were taken from the human foot; it is hardly probable that any of those used in the later centuries were so. The name has been perpetuated from a very early time; but the thing named has either lost by degrees its original value, or it has been arbitrarily changed. As to the origin of the British foot, it is pretty easily explained. There is no reason to doubt the account commonly given of the adjustment of the yard from the arm of Henry I., in 1101. The foot is certainly derived from the yard, which has always been the standard of length in England, and is simply the third part of that measure. I know that we are continually told that our American foot is in length but a fraction in excess of the average foot of man. It astonishes me that any one who has two feet to walk on himself should ever entertain this opinion. The length of the human foot is given in the *Encyclopedia Britannica*, (authority Dr. THOMAS YOUNG) as 9.768 inches. Upon how large an extent of observation this determination is founded, is not known; but the question in issue is pretty well settled in the volume of "*Investigations in the Military and Anthropological Statistics of American Soldiers*, by Dr. B. A. GOULD," published among the Memoirs of the U. S. Sanitary Commission in 1869. Nearly 16,000 individual men, volunteers for the army, of very various races and nationalities, were subjected to measurement, of whom about 11,000 were white and the rest colored. Dr. GOULD says: "The mean length [of the foot] was found for no nationality to exceed 10.24 inches; and for none to fall below 9.89 inches; the value for the total being 10.058 inches," or about a twentieth of an inch above ten inches. This approaches much more nearly to a quarter of a metre than to a third of a yard. Let it be understood that nobody is objecting to the foot measure. It is a very convenient measure to have. If it were slightly modified so as to be equal to three decimetres, it would be more desirable still; but it is quite unnecessary to defend it on the ground that it is the measure of the human foot; and it is judicious not to do so, because that happens not to be the case.

However, the facility of measuring off the yard on the arm is a fact which furnishes to the objector firmer ground. We *can* do that. Sir JOHN HERSCHEL's rule is, "Hold the end of a string or ribbon between the finger and thumb of one hand at the full length of the arm extended horizontally sideways, and mark the point that can be brought to touch the centre of the lips, facing full in front." Very well; now if you will carry the string or ribbon entirely across the lips and mark the point that can be brought to touch the angle of the jaw or the lobe of the ear, you will have a metre. Or, if you carry the ribbon across the breast instead of the lips, and bring it to the point characteristic of that part of the person, you will have a metre once more.

The breadth of the palm is a decimetre; the breadth of the little finger at its extremity is a centimetre. A pace is an artificial step, and not a natural one; but suppose that it were natural for us to stride three feet, or, suppose, at any rate, that we have learned to do so; and suppose that a metre is too large a step to be easily acquired; a pace is practically nine-tenths of a metre, and any number of paces are reduced to metres by dropping a

tenth part. Thus, fifty paces are forty-five metres, and one hundred paces are ninety metres. This reduction is the simplest of all possible processes. Thus, I do not see that, by adopting metrical measures, we are going to be in the slightest degree disabled from finding, in the dimensions of our own persons or of our steps, all the means of effecting rough measurements which we possess at present; and this objection falls to the ground.

But there is still another practical objection which is so perfectly well founded that I hardly know what to say about it; so that I am not sure that the truest wisdom in me would not be to let it alone altogether. It is the undeniable truth that, *if we give up our present measures we shall cease to have them any longer.* "What follows?" say your committee with anxiety: "we have blotted from the mind of the nation the foot and a knowledge of every measure into which it enters as a unit." This is evidently a serious business. It reminds us of the sad case of the lad, who, having eaten his cake, desired to have it again. The committee go on to explain that, instead of twenty-five feet we shall have to say something else; and instead of one hundred and forty-five miles we shall have to say something else still. And exploring the extent of the calamity, the committee become gloomily figurative; and speaking with deep emotion of "the cubic foot, known wherever the English language is spoken," they tell us that this cherished object "is also gone, and in the twilight of its existence, we grope about for a substitute." I do not deny that this is eloquence; but I respectfully submit that it is not argument. There cannot but be some of us who will consider that this tenderly lamented cubic foot, with its inconvenient numerical relation to the cubic inch of 1728 to 1; and its more inconvenient relation to the common unit of liquid capacity of 1728 to 231; and its even still more inconvenient relation to the unit of dry capacity of 1728 to 2,150.42, is very well out of the way.

I will not attempt to follow the committee further in their lament. But I cannot omit to notice, in passing, the perplexing embarrassment of the honest man who, setting out to purchase the convenient quantity of fourteen pounds of beef for his dinner, after there have ceased to be any pounds, is astounded at finding that he will be compelled to pay for the amazing number of grammes expressed by the figures six thousand three hundred and fifty-six: or in case that he is bankrupted by this huge demand, will be permitted to compromise the matter only on condition of buying six kilogrammes, three hectogrammes, five decagrammes, and six grammes. I wish to present a parallel to this. I go to my tailor for a coat, and he states to me the price, in a sum expressed by the four digits named above, in the same order, viz., 6, 3, 5, 6. The committee has given the general rule for reading concrete decimal numbers, as follows: "All the readings are made in the lowest unit." Hence, the cent being the lowest money unit involved in the price named, my tailor is under the necessity of informing me that I can have the coat for six thousand three hundred and fifty-six cents; and it will not be lawful for him to vary the form of expression in any manner unless to say, by way of alternative, that he will give me the coat for six eagles, three dollars, five dimes and six cents.

I would, however, advise the unfortunate man who finds so much trouble with his marketing, not to buy his meat by the pound after pounds have gone out of date; but to content himself with a round six kilogrammes, or, in case he is very hungry, say six and a half.

As it respects the objection that the introduction of the new measures would invalidate the titles to lands held under old surveys, nothing can be more imaginary. No legislation on this subject can be retroactive—it would not be constitutional if it were. The registry of deeds in the past would continue to have the same validity as now. In making a new deed in the future nothing would be easier than to translate the language descriptive of linear and superficial dimensions from one form of expression to the other. Changes should thus come on gradually, as property should change hands. Deeds have to be made anew when sales are effected, and only then. The labor of making them in one form or the other is precisely the same.

One final objection, or pair of objections allied to each other and closely connected together, I have reserved to be considered last. Some gentlemen honorably eminent in science have criticised the metric system on the ground that its base is not well

chosen. This base purports to be the ten-millionth part of a quadrant of the terrestrial spheroid. But it is said the earth is not a spheroid, being rather an ellipsoid of three unequal axes; whence it follows that the meridians are unequal, and that the metre, if truly the ten-millionth part of one quadrant, is not a ten-millionth of any other differently situated in the ellipsoidal surface. The polar axis of the earth, on the other hand, is the common minor axis of all meridians ; it is a magnitude entirely unique; and, even if the earth were a true spheroid, there would be a higher degree of scientific fitness, there would be something on which the mind would dwell with more entire satisfaction, if we should take a fraction of that axis as the base of a system of metrology, than a fraction of any quadrant, or any other known magnitude. This is the view of Sir John Herschel and of Capt. Piazzi Smyth, and if the whole thing were to be done over again, it would probably be the unanimous view of the scientific world. But the matter has gone too far now to change the base. In the meantime, therefore, there is no impropriety in saying, that it is by no means yet proved that the earth is an ellipsoid. Neither, indeed, is it proved that it is a spheroid, if by that word is to be understood a figure geometrically true. What *has* been proved may be understood from the following succinct statement.

There have been measured upon the surface of the earth, in all, excluding re-measurements, some sixteen meridian arcs. Most of these are very short, not exceeding three or four degrees in length, and generally less than two. The longest of them all is the Russian arc, of twenty-five and one-third degrees ; and the shortest, the first Swedish arc, measured in 1737, by Maupertuis, of fifty-seven and a half minutes. Two short arcs have been measured on the American Continent, one in Peru and one in Pennsylvania. The latter, only about one a half degrees in length, was measured by Messrs. Mason and Dixon in 1767, without triangulation, and is esteemed of comparatively little value. The Peruvian arc, which is rather more than three degrees long, was admirably triangulated by Bouguet and La Condamine, in 1735, and the two or three years succeeding. A short arc of about a degree and a half was measured at the Cape of Good Hope by Lacaille in 1751. In this measurement, the effect of local attractions on the plumb-line was such as to lead to very erroneous conclusions. This arc has been recently re-examined and extended to more than four and a half degrees, by Messrs. Henderson and Maclear; this operation bringing to light the causes which had vitiated the former. A long arc of twenty-one and a third degrees has been measured in India. With the exception of the Indian, the African, the Peruvian, and the Pennsylvanian arcs (the last hardly meriting to be included in the enumeration), all the rest are in Europe, and are embraced within limits of longitude differing, at widest, but about twenty-seven degrees.

Now supposing the earth to be a spheroid, it matters not, for the determination of its figure, what are the longitudes in which meridian measurements are made, provided the latitudes are different; for on this supposition degrees in the same latitude are equal everywhere. Also, if the spheroid is oblate, the curvature in the higher latitudes will be less and the degrees longer than in the lower. Now, as in an ellipse the linear amplitudes of any two arcs differently distant from the apsides, along with the angles made by the normals at their extremities, suffice to determine the axis and the eccentricity, it was to be expected that a comparison of any two properly selected meridian arcs measured upon the earth's surface in different latitudes, would furnish constantly the same value of the polar and equatorial diameters, and the same value for the compression of the poles. But this expectation has been singularly disappointed. The international scientific commission which, in 1799, fixed definitely the length of the metre, in comparing the French arc with the Peruvian arc, made the compression of the earth one 334th: but Messrs. Laplace and Legendre, both eminent geometers, members of that commission, by comparing one portion of the French arc with another, made it, the first 1-150th and the second 1-148th. Delambre, one of the geodesists who effected the measurement, deduced from his comparisons with the Peruvian arc, the value, one 312th, and afterwards one 309th. The French arc was subsequently extended southward nearly three degrees more; making a total length of twelve and one third degrees, when a recomparison

with the Peruvian arc by DELAMBRE gave a compression of one 178th. The effect of these differences of result upon the calculated length of the quadrant of the meridian passing through Paris would not be very great, upon the hypothesis that the earth is really a spheroid ; for it happens that the French arc is so situated as to give very nearly the value of the mean degree, independently of the eccentricity. But if the earth is an ellipsoid, it is evident that it is entirely wrong in principle to compare two arcs with each other, when they differ materially in longitude.

Now it is a part of the history of this subject that, in the year 1859, Gen. T. F. DE SCHUBERT, an officer of the Russian army of distinguished ability, after a laborious series of comparisons of several arcs combined two by two in all possible ways (the arcs were eight in number, and the combinations twenty-eight), found such remarkable discordances, that he felt himself forced to the conclusion that the earth is not spheroidal, but must be ellipsoidal in form. The compressions found by him varied, for instance, between the wide extremes of one 14501st, and one 116th; and the difference between the largest and smallest value for the polar axis amounted to 362,126 feet, or 68.584 miles.

Now observe what these deductions prove, and what they do not prove. They prove certainly that the earth is not a perfectly regular spheroid, and in this they are corroborated by other evidences; but they do not prove it to be an ellipsoid. The corroborating evidences just alluded to may be slightly glanced at in passing. In the first place, the successive degrees of the French arc do not increase, in going northward, in the manner they ought if the meridian is truly elliptical. And, secondly, it is true, that after that arc had been extended southward, as above-mentioned, to the Island of Formentera, in the Mediterranean, the degrees at the southern extremity were found actually to diminish in going northward, instead of increasing, as in a regular ellipse they should have done.

Colonel EVEREST also, the accomplished geodesist, who executed the measurement of the northern section of the great Indian arc, found that, when he compared the northern half of the northern section with the southern half of the same section, he obtained an eccentricity of one 192d; but that when he compared the southern half with of the northern section with the whole southern section, the resulting ellipticity was only one 390th, or one-half as great. The values of the polar axis of the earth also, obtained from these comparisons, differed by 67,106 feet, or about 12.71 miles.

These facts (and many like them might be stated) are to be borne in mind in judging how far the method of General DE SCHUBERT, with the data thus far gathered to go upon, is to be trusted. This gentleman, concluding very properly that comparisons of arcs measured in different longitudes are unworthy of confidence, resolved to deduce values of the polar and equatorial diameters of each meridian, by such comparisons as that of Colonel EVEREST just described. But here his material is at once largely reduced; for of the eight arcs employed in his previous comparisons, only three are long enough to permit the application of this method, viz.: the Russian, twenty-five and one-third degrees ; the Indian, twenty-one and one-third degrees, and the French, twelve and one-third degrees. The British arc is now long enough to allow a fourth comparison (ten and a quarter degrees), but it is so nearly in the meridian of the French arc that it may better be treated as a prolongation of that. Gen. DE SCHUBERT divided each of his three arcs into two parts each, as nearly equal as convenience would allow. From each he deduced a value for the major and minor axis of the meridional ellipse. If his hypothesis was true, the minor axes should have come out equal and the major axes unequal. The latter anticipation was realized, but the former only imperfectly so. The polar axis found from the Russian arc, compares pretty well with that found from the Indian; differing only about fifteen hundred feet, or rather more than a quarter of a mile ; but the difference between the values of the same axis, as deduced from the Russian and the French, is fifteen thousand one hundred and sixteen feet, or nearly three miles. On account of this discrepancy Gen. DE SCHUBERT discards the French arc in this computation, and determines a value for the polar axis on the basis of the Russian and the Indian alone ; giving, at the same time, quite arbitrarily, twice the weight to the former as to the latter. And with

the axis thus determined and the aid of the Peruvian arc, he finds a third equatorial radius; which, combined with the Indian and Russian equatorial radii, enable him to place the axis of his imaginary equatorial ellipse. Finally, with the axes of the equator and their longitude, and also the equatorial eccentricity, he is able to compute the length of the equatorial radius corresponding to the French arc; and from that, the length of the theoretic French quadrant. Then, comparing this theoretic quadrant with the length of the same as deduced from the actual measurement of its ninth part, he feels himself justified in pronouncing the metre to be too short by the two hundredth part of an inch. I think it does not require a profound mathematician to see that the data on which this conclusion rests are too meagre to justify so important a deduction. The case is one to which Prof. HUXLEY's witty remark upon the power of the mathematics may be properly applied. "The mathematics," observes the Professor, "may be compared to a mill of exquisite workmanship, which grinds you stuff of any degree of fineness; but, nevertheless, what you get out depends on what you put in." And here it appears to me that we are not yet prepared to put in material enough to furnish us with a grist worth carrying away.

Prof. AIRY perceived the weakness of this method and pointed it out. He suggested an improvement on it which is worth more, and his suggestion was taken up by Captain A. R. CLARKE, an accomplished officer connected with the ordance survey of Great Britain. This method consists in bringing together the latitudes, determined both geodetically and astronomically, of as many stations as possible,upon selected meridian arcs; and then, all the elements of the problem being left indefinite, proceeding to ascertain what values given to the indeterminates will make the sum of the squares of the errors of latitude a minimum. He first presented his results to the Royal Astronomical Society, in 1860; and afterwards, having slightly modified some of his data, republished them in an appendix to a large volume issued in 1866 by the Royal Ordnance Survey. His last conclusion puts the metre in error one 172d of an inch. The number of latitudes employed by Capt. CLARKE in this investigation is forty. Some slight variations made upon a portion of those in the Russian and the French arcs, between the first and the second determinations, amounting generally only to very small fractions of seconds, produced a sensible difference in the length of the polar axis, in the value of the compression, and in the computed error of the metre; reducing this last from one 163d of an inch, which was his original determination, to one 172d, as given above. But Capt. CLARKE himself regards the data as entirely insufficient to make a correct determination of the earth's figure a possibility. His own words are: "It would scarcely, I conceive, be correct to say that we had proved the earth not to be a solid of revolution. To prove this would require data which we are not in possession of at present, which must include several arcs of longitude. In the mean time it is interesting to ascertain what ellipsoid does actually best represent the existing measurements." And having found this, he proceeds next to apply the same method, *i. e.*, the method of least squares, to the object of ascertaining secondly, what *spheroïd* will best represent existing measurements; and he is brought thus to the conclusion that such a spheroid is nearly as probable as an ellipsoid; the numbers representing these probabilities being 154 and 138 respectively (where the smaller number indicates the greater probability). We may admit then that the ellipsoidal theory is slightly the more probable; and with this preliminary we are prepared to consider the two objections spoken of above.

The first is, that the earth's meridians being unequal, the ten-millionth part of a quadrant, even if we had such a measure correctly, could be only the ten-millionth of one particular quadrant, so that the ideal of a natural standard everywhere present and belonging equally to all the world must be abandoned. Still it cannot be denied that the quadrant chosen, though a particular quadrant, possesses the essential property of a standard, that is to say, invariability, quite as completely as if all the quadrants were equal. If this natural standard were intended to be, or were capable of being made, a standard of convenient reference, and not merely a standard of value, if, in other words, a tradesman, suspecting his metre to be in error, could adjust it by simply stepping out of his door and applying it to

the earth's meridian, there might be some reason for complaint on the part of those, and they would be the majority of mankind, whose distance from the standard would deprive them of this facility. This not being the case, no practical disadvantage arises out of the inequality of the meridians, and it is only the simplicity of the original conception that suffers.

The second objection to the base of the system—an objection which is often urged in a tone which implies that the objector regards it as nothing less than fatal—is that the metre is not, after all, exactly the ten-millionth part of the particular meridian from which it was derived. It is possible that it is not: nay, we may safely assert that it would be nothing short of a miracle if it were. We have glanced at the condition of the problem of the earth's figure and magnitude in the hands of the geodesists. We have seen that every meridian measurement which has yet been made has served but to accumulate evidence that this figure is not geometrically regular, and is not probably, if words are to be applied with severe exactness, either a spheroid or an ellipsoid. It will easily be understood that a local irregularity actually affecting but a limited extent of a terrestrial arc, may, when it is allowed to give character to a whole circumference, lead to extraordinary conclusions; and we have seen the fact that it will do so, illustrated in the examples cited from Col. EVEREST and others. What hope can there be that the effects of such irregularities can be eliminated by an investigation which, however admirable in principle and however ably wrought out, rests on a comparison of only forty latitudes? Not a single geodetic measurement has yet been made in all the immense expanse of northern and eastern Asia, of northern and central Africa, or of Australia and the Australasian archipelago. Nor, except in the small Peruvian arc, and the still smaller Pennsylvanian, which latter does not count, has the great American continent made any contribution to the solution of the difficult problem under consideration. When we consider, therefore, that the introduction of minute corrections, amounting only to small fractions of seconds, into only a part of the data employed in Captain CLARKE's equations, suffices to modify the resulting dimensions of the earth to such an extent as to produce, as we have seen, a very sensible change in the calculated value of the error of the metre, I think that the assertion just now made will be admitted to be perfectly well founded, *i. e.* that if the length given originally to the metre had been exactly the ten-millionth part of the Paris meridian, this result would have been neither more nor less than a miracle. I may further add that, even if the metre had been quite correct, its authors could not have known it to be so, and we should not know it to be so now. When measurements shall have been made in those vast regions just mentioned, which have not yet been attacked by the geodesists, and when, instead of forty latitudes, four thousand shall have been thrown into the hopper of Prof. HUXLEY's mill (though I confess that in such a case I should not be envious of the miller's task), we shall get out an inevitably different and a very certainly more satisfactory grist than has yet been ground for us. In the mean time we may as well take the metre as we find it, and not concern ourselves about this Protean and microscopic fraction of error, which has so long been thrown up to it as a reproach.

It is a little remarkable that the objectors who find the error of the metre to be so grave a blot upon its character, should nevertheless agree in urging us to accept a standard derived from another natural dimension of the earth, equally invariable no doubt with the quadrant, but at the same time equally unmeasurable—the polar axis or the polar radius. This is a dimension of which the authorities give us as many different values as they give of the quadrant; and of which they are sure to give us a new one every time an addition is made, no matter how trivial, to the data from which it is deduced. The values fluctuate perhaps between narrower limits of variation; and if the ten-millionth part of the earth's polar axis or the earth's polar radius were our theoretic metre, the absolute error of our practical metre would be probably rather less in proportion to its length, than that of the metre now in use. But the error would be there none the less; for, as before, it would be nothing short of a miracle if it were not; and between two errors, both of them microscopic, and neither of them affecting any conceivable human interest,

I see for my own part little to choose. If the advocates of the radius metre could come to the defenders of the quadrant metre, and say to them, "Here, you see, our metre has no error at all, and yours has one," the case would be a strong one; but that does not seem to be the case. Since these things are so, why then, you may inquire, should we endeavor to fix our standard of length with reference to either axis or quadrant or any other dimension which we do not know, and which it is perfectly certain that we shall never be able exactly to ascertain? That, gentlemen, is a question which you may very well ask, but which I shall not attempt to answer. I accept the metre as it is, not because it is the ten-millionth of the French quadrant (though, according to Capt. Clarke, it *is* the ten-millionth part of the quadrant passing through New York, within less than the ten-thousandth part of an inch), but because it is the actual base of an admirable system of weights and measures already in use among one hundred and sixty millions of people, rapidly growing in favor among those who have not yet adopted it, and destined in my belief to be sooner or later the system of all the world.

But, gentlemen, I do not expect that this system will make its way in the world against the will of the people of the world. I do not expect that our people, and I do not desire that any people, shall be coerced into receiving it by the force of "imperial edicts" or the terror of bayonets. What I do expect is, that they will sooner or later welcome it as one of the greatest of social blessings. What I do expect is, that they will one day become conscious of the many inconveniences to which they are subjected from the anomalous numerical relations which connect, or rather we might say, disjoin, the several parts of their present absurd system; inconveniences which they have learned to endure without reflecting on their causes or suspecting that they were unnecessary in the nature of things: and that when fully at length awake to the slavery in which they live, they will burst its shackles, and rejoice in the deliverance which the metric system brings. This cannot take place, of course, until the people are thoroughly informed. There are influences, therefore, which are now only beginning to operate, which must first have their full course before the results I anticipate will make themselves manifest. The first and most important of these is the education of the young to a thorough understanding of this system, and a perfect familiarity with its practical applications. The metric system must be taught in all our schools. It ought of course be taught there, as being the system actually in use among nearly or quite half the inhabitants of the civilized world already, and without any regard to the question whether it is to be ours or not. But it ought to be taught, too, with special reference to this question; in order that another generation may meet it and settle it intelligently. And I think I hazard nothing in saying that when one generation shall have grown up into whose minds this knowledge shall have entered along with the first rudiments of their learning, the question will no longer have two sides.

But, in the second place, the system should be practically illustrated before the eyes of our people, by being introduced into our custom-houses, and made the guide according to which duties are assessed and collected. This measure will disturb the habits of no one in the affairs of ordinary life. Importing and exporting merchants will interpose no objection to the change. On the contrary, they will welcome it as greatly diminishing the amount of computation which they are now compelled to make. It is, in fact, the complaint of Capt. Fiazzi Smyth, that it was the pressure of the commercial class which came so near to making the metric system the exclusive system in England in 1868. Our tariff laws will require transformation; but that transformation may be made without in any manner disturbing their essential provisions: so that no trouble need arise from this cause. What it is here proposed to do is nothing more nor less than what was actually done, some thirty years ago, by all the members of the German Zoll-verein. And though the state of things produced by it there will be superseded on the first of January, next, by the extension of the metric system in full over all the component states of the late North German confederation, if not over the entire German empire; yet it will still exist in Austria, and will continue to ex-

ist in that empire until she, too, shall adopt the same system for her domestic affairs likewise.

By degrees our Federal government may introduce the metric weights and measures into our public surveys; such as the coast survey, the several boundary surveys, the geological, topographical, and land surveys of the territories, and the surveys of the lakes. In the published reports of these works, or at least in such of them as are intended for, or are likely to have, a large circulation among the people, it would be advantageous, and would familiarize metric values to the popular apprehension, if dimensions, quantities, and weights should be expressed both in metric denominations and those of the existing system.

The metric weights and measures may further be introduced into actual use in the navy yards and military posts maintained by the government in the different parts of our territory: and, finally, the business of the post office department may be largely, if not wholly, conducted, so far as weights and measures are concerned, in metric denominations.

These are measures which were unanimously recommended by the international conference on weights, measures, and moneys, which was convened in Paris, in 1867, consisting of delegates appointed by the governments of twenty-two different nations, including, of those not using the metric system, Austria, Russia, Sweden, Norway, Denmark, Turkey, Great Britain, and the United States. To most of them, as it appears to me, there can be no reasonable objection, even on the part of those who have no admiration for the metric system themselves, and no faith in the prediction of its final prevalence. If nothing follows them, they can at least do no harm.

I have occupied, gentlemen, a larger portion of your time than I intended, and larger, I fear, than will have seemed to you reasonable. The subject itself is a large one, and my interest in it is deep. I am so far from pretending to have exhausted it, that I feel that what I have said is but the merest skeleton of an argument. I wish to be indulged only in a single additional remark, which shall be in regard to the able and comprehensive, and, at times, eloquent report of Mr. JOHN QUINCY ADAMS, which you have republished in the volume along with the report of your committee.

The original publication of that report, able and powerful as it is, and for the very reason that it is able and powerful, I esteem to have been a serious public misfortune. It effectually extinguished all hope of metrological reform in the United States for half a century. And yet Mr. ADAMS, decidedly as he discouraged any legislation, at least for the time being, and apparently for a very long time, looking toward the recognition of the metre in America; darkly as he drew in the lines as he painted the picture of France writhing in the toils which the metric system had thrown round her; and fondly as he lingered over that beautiful system of British weights and measures distinguished by the priceless property of a "uniformity of proportion" of which he laments that there remain to us only the ruins; Mr. ADAMS, after all, was an admirer of the metric system to such an extent, that one is sometimes at a loss to decide whether he seems to love or to fear it most. In the midst of his doubts and his misgivings, he cannot refrain from occasionally enlarging upon its merits, in language strong enough to satisfy even the most enthusiastic of its advocates. And when for a moment he succeeds in forgetting France, and in shaking himself free from the embarrassing associations of the immediate present, he becomes as it were inspired with a spirit of prophecy, under the influence of which he becomes oblivious of difficulties, and glowingly anticipates that very approaching triumph which his own labors are destined so considerably to postpone. No words that I can use can add to the positiveness of assertion with whieh he predicts that final consummation to which I have declared to you to-day that I so confidently look forward. I cannot do better, therefore, in concluding these remarks, to which I thank you for having so indulgently listened, than to adopt his own language, and to express with him the conviction that, "If man upon earth be an improvable being, if that universal peace which was the object of a Saviour's mission, which is the desire of the philosopher, the longing of the philanthropist, the trembling hope of the Christian, is a blessing to which the futurity of mortal man has a claim of more than mortal promise; if the Spirit

of Evil is, before the final consummation of things, to be cast down from his dominion over men, and bound in the chains of a thousand years, the foretaste here of man's eternal felicity; then this system of common instruments to accomplish all the changes of social and friendly commerce will furnish the links of sympathy between the inhabitants of the most distant regions; *the metre will surround the world in use as well as in multiplied extension;* and one language of weights and measures will be spoken from the equator to the poles."

A TUNNEL CHANNEL.

From "The Building News."

The triumph of the Mount Cenis engineers has revived a project which has long been in existence. It is nothing less than the tunnelling of the British Channel; and there are not wanting practical persons who, while appreciating the difficulties of the work, believe them to be by no means insuperable. We hear so much of the tedium, delay, and annoyances accompanying the present system of transit between France and England, that, no doubt, such a scheme, if shown to rest upon any probabilities of success, would be undoubtedly and universally welcome, though the tourists of the actual day could scarcely hope to derive much personal benefit from its execution. No doubt the generation which has created the Suez Canal and perforated the Alps has reason to put faith in its power of accomplishing other similar achievements, upon an even grander scale; but there is a vast difference between scooping an open channel through a desert, or hollowing a road with a mountain as its roof, and constructing a safe and solid highway with a peculiarly restless sea pressing upon its arch, and forever chafing against the superincumbent mass. It is true, beyond question, that an immense progress has been made since the Thames Tunnel was regarded as a miracle of engineering and a wonder of the world; yet a Channel tunnel would be an almost wholly dissimilar undertaking. Still there are men with sagacious heads, not likely to dream, who think the performance quite possible, and who would be willing to enter upon it, provided the one great necessity—an adequate capital—were furnished. One proposal is to avoid the chalk altogether, and following the Wealden, which contains prodigious masses of clay, extending from Dungeness to Cape Griznez, to burrow at a depth of 100 ft. below the bed of the sea, which, it is affirmed, could then be as easily kept out of it as the London pavements out of the London sewers. There is a rival line—on paper—from Dover to Calais; but we need not compare the two plans in detail. Both would run at an equal depth; the difference in point of distance would be only $1\frac{1}{2}$ mile, and as a means of communication, the one would probably possess a little or no superiority over the other. The question, apart from absolute technicalities, is, are we likely to see this mighty enterprise taken in hand and completed? Now, as to its being an impossibility, that idea may be dismissed; but would it be worth the while of governments and speculators to assume the gigantic task, with all its many and undeniable chances of repeated disappointments and failures, and disasters to human life, of millions sterling swallowed up, of the labor being suspended, of one new capital after another being required, of contractors ruined and shareholders with them, and the sea being paved with more gold than the submarine traffic would ever repay? The engineers who have carried one railway through and another over the Alps, would indubitably not shrink from their own professional share in the resposibility; but there is much more than this to be thought of. They have brought us within a few weeks' journey of India, China, and even Australia, it is true, and it may be expected that before long the most protracted steam voyage from one port to another on the globe need not exceed a month. We are growing accustomed to extraordinary applications of natural and mechanical power. The hydraulic arrangements for lifting enormous weights at Great Grimsby and Birkenhead do not astonish us now. We have ceased to boast about the Bramah press, which gave to a 40-horse en-

gine the power of 1,400, and raised the tubes of the Menai Bridge, each nearly 1,000 tons in weight. The Great Eastern is as familiar, with all her vastness, in England as the giant pumping machinery for the Haarlem lake was to the dauntless industrial genius of the Netherlands. The blows of the Nasmyth hammer, the armor-plates of our iron-clads, the 20 miles an hour speed of the Holyhead packets, the 25,000 tons capacity of the Great Eastern, Krupp's monster artillery, the Cherbourg breakwater, the Bermuda floating-dock, the Liverpool docks, the arch over the Dee at Chester, the bridge of Niagara, the Fell Railway and the Mount Cenis Tunnel, the Atlantic and Pacific Railroad, the "artificial Bosphorus" connecting the Red with the Mediterranean waters—all these are testimonies to the tendencies of our epoch to attempt mechanical triumphs from the very thought of which the engineers of a former period—since the Cyclops and the Egyptians, at any rate—would have shrunk. The money for this Channel subway might doubtless be had; the materials, of course, would be forthcoming, and the difficulties of the work do not alarm the engineers of either country; the question, therefore, seems not far from being reduced to one of commercial calculation. But is a very serious question, notwithstanding, involving, according to the most moderate computation, an expenditure of £8,000,000, which, we should say, is merely fanciful, and as Gibbon said, when writing about Hannibal and his reputed passage of the Alps, a "sterility of fancy" in such matters is above all things else is to be desired.

Now, it may be taken for granted that, to nine-tenths of the people, at least in certain weathers, the passage from Dover to Calais, though brief in point of time and duration, is abominable. There is, naturally, a chopping cross-sea in that part of the Channel, due to conflicting tides, winds, and currents, and the steamboats feel the rolling motion all the more for being so small. The question has often been put, why are they so small? The inevitable answer is, because larger vessels would draw more water than the harbors on either side could command. They are all four shallow at low tide, are greatly encumbered by mud and sand, and are much affected by inconvenient winds. The question is, whether to improve them, or to diminish the necessity for their use. Hence the tunnel schemes, which are various. There was talk of iron shafts running up from the bed of the sea as means of ventilation. Then followed M. Favre's plan, in which the tunnel, like Mr. Remington's, was to be 100 ft. below the level of the sea-bed; shafts sunk through the water and clay were to furnish facilities for excavating the great hollow and supplying it with air; and the trains were to be propelled by atmospheric pressure. The subsequent ideas of Mr. Nicol and Mr. Austin were, the one for a tunnel lined with an iron tube, the other for 3 parallel ways cut at a depth of only 60 ft. below the weight of the water. But these imaginations were eclipsed by that of M. Thomé de Gamond, who proposed a tunnel ventilated by conical shafts, two of which were to be of such gigantic dimensions as to permit of winding roadways through their interiors, to a station buried 100 ft. down in the clay. Some one has astutely observed: "It is dangerous to laugh at engineers, for they have the knack of turning the laugh against us, by doing things which we have pronounced impossible;" nor are we speaking of impossibility in this case, when Mr. Hawkshaw, Mr. Brunlees, and Mr. Remington have recorded their opinions in quite an opposite sense. But the question is not entirely that of a tunnel. Mr. Bateman, whose authority will not be disputed, declared that he could construct a railway on the actual bed of the sea, and avoid the necessity of excavating beneath it. The proposal, however, was, so far as we remember, not altogether his own. More than 50 years ago, two distinguished Frenchmen, MM. Tessie de Mottray and Franchot, suggested that a cast-iron tube might be laid and secured across the bed of the Channel from Calais to Dover, of proportions to allow of wheeled vehicles to pass. Another Frenchman, M. Payerne, preferred masonry to metal, and wanted, by the assistance of the diving-bell, to build a causeway from shore to shore of brick or stone. Mr. Winton thought of a railway in an iron casing; Mr. Zerah Colburn would have sunk his tubes, put together on the land, in lengths of 1,000 ft. each; Mr. Chalmers developed a magnificent notion, which would cost £15,000,000; Mr. Cowan fancied an iron shell lined with concrete; and Mr. Page,

engineer of the new Westminster Bridge, declared for building on shore 8 conical shafts of iron, towing them out, sinking them, and filling in with concrete the space between an inner and outer skin. A lighthouse was to be erected at the top of each, while at the bottom would be, of course, openings to the tube, which would be constructed in ¼ mile sections, sunk, and joined by workmen descending in diving-bells. When some engineers asserted that men could not work under such an overwhelming pressure of water, Mr. Page affirmed that he could get rid of this difficulty with perfect ease. And so would Mr. Bateman, though in a different manner; he puts faith in a tube, but of a different construction, 13 ft. in diameter, and 4 in. thick, built up in sections, and put together within a peculiar kind of air-tight chamber, at the bottom of the sea, to be pushed on as the work advanced, by hydraulic pressure. But then arose a practical inquiry, on the part of a doubting man: "You would have 60,000 joints in your tube, any one of which might get into trouble, and what would you do then?" Which problem we are far from undertaking at present to solve. It is only a sketch of the idea, and its history, that we are offering. Then, there has been the plan of a floating corridor, so to term it, midway between the bed and the surface of the sea, calculated to float at a depth of 40 ft. or so, and steadied by mooring chains and anchors, with immense granite piers on both sides, at either end, and cork-screw staircases. The proposal is meritorious on account of its courage, and of little else. Much the same may be said of the Babylonian projectors who undertook to erect a bridge, right across, on 400 piers, at a stupendous height, or to carry one across the sea level, with pivot openings and drawbridges for the passage of ships, or to rear a structure for arches of 500 ft. span at an elevation beneath which all her Majesty's fleet could sail. We are bound, for the time at least, to dismiss many of these schemes as chimerical. There is, however, the project due, we think, to Mr. Fowler, of a steam floating bridge, in the shape of an immense flat ferry-boat, adapted for an exact touching, at particular times, of either shore, below certain towers, considerably advanced into the sea, where from an embankment the vessel could be raised or lowered, at any level of the tide, to an eveness with the railway. We have had similar plans roughly drawn by Mr. Chinie, Mr. Daft, Mr. Grantham, and Mr. Bridges Adams, besides one by Mr. Galloway on a less ambitious scale. The most elaborate of them, however, include the opening of at least two large and costly new harbors, whence the monstrous craft might be received and dismissed, works sufficiently easy on the English side, but presenting obstacles of serious magnitude on the French coast, since Calais is radically a bad port, while Boulogne is not far from being as unsuitable. The point selected by Mr. Fowler was at Andrecelles, situated between Boulogne and Calais, where there is deep water, no sand, and ample shelter. This would reduce the distance from London to Paris by 14 miles, the time occupied on the journey by two hours. Whatever may be the choice, in the end, of public opinion, it is not likely that the saying of Capt. Tyler will be permanently disregarded: "Frequently the traveller from India or America finds the British Channel the most unpleasant part of his transit, and he as often looks forward with more anxiety to the state of the Channel than to the heat of the Red Sea or the winds of the Atlantic." There can be no doubt concerning the absolute truth of this. But still more does it apply to the common passenger traffic across the Straits of Dover. The boats, as a rule, are confined, over-crowded, and ill-ventilated; women and children, in foul weather, are crammed into a cell, ironically called a cabin; the transport of merchandise is upon an equally unsatisfactory, if not discreditable system; more is lost, in value, on the quays and wharfs than in hundreds of miles of railway carriage; and how long will it be before some alteration takes place? We leave the grander projects, for a moment, out of sight, to quote some details of that which has been found practicable elsewhere. Boden-See, or Lake Constance, is a fresh-water lake, about 60 miles long by about 10 or 12 wide. It separates Austria, Wurtemburg, and Bavaria from Switzerland, and stops direct railway communication between Switzerland and those countries just as the British Channel does in the case of England and the Continent. "It was impossible to carry the railway round the lake, as the natural barrier which this forms is pro-

longed at its extremities by the impassable Alps"—impassable no longer, for this report was written some years ago. "Consequently, the goods traffic of Germany with Switzerland and the South of France, which is considerable, was exposed to delay by transhipment, to the great inconvenience of every one interested in it. Under these circumstances, Mr. Scott Russell, who had built the first fast steamer navigating the Boden-See, was asked by the Swiss Railway Company whether he could undertake to design a vessel by which railway trains and locomotives could be carried across, with the understanding that no machinery of any kind should be required to put the trains on board, except the ordinary locomotive engine." His prompt answer was in the affirmative. There were two small and shallow harbors, allowing of no more than 6 ft. draught. At each a structure was stationed for the traffic, nominally a ship, but answering all the purposes and having all the appearance of railway stations, with platforms, offices, and refreshment-room, double-decked, with two rudders, and independent paddle-wheels. The description goes on, the placing of the trains on board the ferry is a very simple operation. They are transfered by means of a bridge, suspended in the air by heavy weights, capable of adjustment to the rise and fall of the water, which, although it is a lake which is in question, has a periodical variation of about 10 ft. Carriages intended to cross the lake are left at the siding, which leads to the ship; the locomotive which does the ordinary work of the station comes and pushes the train on board, and, once there, special precautions are ready to prevent its breaking loose, and the whole operation takes rather less than 5 min. It may reasonably be objected that Lake Constance is not the British Channel. It is not an enormously over-crowded maritime highway; it has no Atlantic billow and no heavy ground swell; but it has the short, sharp, chopping waves characteristic of the Dover Straits. Says Mr. Scott Russell, "the advantage of taking your bed-carriage in London, and not having to leave it until you awake in Paris, need not be enforced." Between the politicians who maintain that "the thin streak of sea-sickness" separating our island from France is our natural fortress, and the tourists who want it abolished, what can be said? For ourselves, we have nothing to do with the politicians, and trust that, in the long run, the engineers may decide the question among themselves.

RAILWAY DEVELOPMENT, ENGLISH AND FOREIGN.

From "The Builder."

We have arrived at a period of crisis in railway development. It is not that any new impulse has been given either to our mechanical skill or to our commercial prosperity. It is not such a start as was due to the first triumph of the genius of Stephenson, or the first practical outcome of the business capacity of George Hudson. It is due to no single event of magnitude; although the successful accomplishment of some of the greatest feats of engineering have recently been commemorated. But the general result of the engineering of the last 40 years, when undisturbed by the avidity of speculators, is such as to indicate further progress. From all parts of the world the same signs are manifested. The Alps no longer exist as a mountain barrier necessary to be crossed in the route from Paris to Brindisi. The Isthmus of Suez no longer forms a material bar compelling our ships to double the Cape of Good Hope. The eastern and western shores of the great American Continent are linked together with an iron band. And projects for a direct line of communication from our old *tête de pont*, Calais, to the capitals of our Indian Empire, are assuming more than a visionary probability.

Connected with, or at all events most significantly contemporary with, these wide-spread fruits of the skill and patience of the civil engineer, is the march of a movement in our railway economics at home which has long been urged by one or two far-seeing men. Two of our largest railway companies, one of them the father of all our iron lines (for it has absorbed its own parent, the Liverpool and Manchester), the annual income of which amounts to a seventh part of that of the

State itself, have agreed to make common cause, and to share a common purse. The example set by the London and North Western and Lancashire and Yorkshire railways cannot fail to be widely followed. It has, of late, become pretty clear that the main enemies to railway dividends have been railway directors. The spirit of actual hostility, the desire to injure a rival undertaking, at whatever cost, has been, perhaps not extinguished, but rendered practically powerless, by the absolute necessity to stop reckless outlay, and to close capital account. This was the first victory gained by the shareholders over the boards of management. But with new lines abandoned, and Parliamentary contests suspended from pure inanition, the individualizing spirit still ruled the several Boards. The whole some, practical, eminently paying idea of a great railway federation was scouted. It may be extremely unjust to attribute to railway directors, as a body, any but the best and purest motives. Still, human nature is human nature ; and any steps that might tend to destroy the power, patronage, and position enjoyed by the chairman and leading members of the various boards of directors could not fail to excite an instinctive repugnance on their part. Thus the period of actual waste, of flinging away money by handfuls in the construction of unnecessary lines, has been succeeded by a period of passive waste. Attention has been given, indeed, with more or less wisdom to the development of the resources of individual lines. But the immense advantage to be obtained by the common adjustment of all details of the traffic of the country, by a system of through tickets, by the abandonment of duplicate trains and of the general ignoring, by one line or set of lines, of the existence of their neighbors, has been hitherto obstinately neglected.

How great an immediate return to the shareholder is to be secured by a wise and practical federation, it is not easy to tell. In the case of virtually rival lines, such as those which have so long wasted the great resources of the south-eastern district, the result would probably be the most immediate. Where there are two or three routes available between the same *termini*, the arrangement of the trains on the several lines so as to quarter the day is a duty of the most obvious nature. It is one that has been almost invariably neglected. Yet the saving in the unnecessary trainage miles run that could thus be effected, without any loss of total revenue, would form a very appreciable item in the half-yearly accounts. Thus far the mere common-sense idea of self-protection at which our coach-owners, after a good bout at competition, usually arrived, might have been thought enough to render Bradshaw a volume of much greater unity of purpose than is actually the case. But then, it is true, the competition for the best time of the day—for the 9 o'clock morning train, for instance—might require some mode of arbitration. Everything, therefore, points in the direction of what our French neighbors would call syndicating the earnings of the lines. A common purse, to the common advantage of all, will lead to unity or community of management. That, before very long, some organized federation of our immense traffic companies will be carried out, there is every reason to believe.

While the actual saving thus to be effected is large, it is nothing as compared to the stimulus that will be given to our internal traffic by the removal of the present petty and unnecessary obstacles. The politico-economical theory of supply and demand may be said to be inverted in the history of our English railways. It has not so much been the case, that the need of men to travel has led other men to supply improved means for so doing, as that the supply of accomodation, far more extensive and available than its projectors originally contemplated, has developed an enormous capacity for internal circulation, both of passengers and of goods. Every railway journey taken by any individual may be thought to lead to other journeys by other individuals, and to a corresponding increase of activity in postal, telegraphic, and mercantile interchange. Whatever may be the limit to this self-augmenting activity, there are no signs that we have attained or even approached it. When we see what has been effected by every instance of well-planned junction, and judiciously extended accommodation, we cannot doubt, that if the union of design and aim, for which the physical means for the most part already exist, be adopted by our leading companies, a great and rapid increase in traffic of all kinds will be the immediate result.

This result will, in the first instance, benefit those who may be thought most entitled to the advantage—the holders of the ordinary stock and original shares of the railway companies. For the improvement which has followed a few years of failure in the railway system has been such as to lead us to this point. Preferential charges are now, as a rule, fully discharged out of profits. Debentures, debenture stock, and preferential shares of all kinds, are already satisfied. The surplus profit belongs to the original shares ; and as the proportion of capital over which every rudiment of new profit has to be spread is so much less than the gross capital by aid of which the earnings are effected, the rise of dividend will be very appreciable. The last half year has shown this to be the case. The summer dividend of 1872, if the one-purse system shall have been extensively adopted by that time, may recall the golden days of 1845.

Our internal communication, within the memory of not more than two generations, have experienced three great eras of improvement. We anticipate the arrival of a fourth. The first of these was the great change wrought in our highways by the adoption of the simple, common-sense plan which Macadam first induced the Bristol Road Trust to introduce, although in the plains of Apulia it had been in practice from the time of Trajan. As far as the employment of horse-power, for speed and for luxury of travelling (though not for the conveyance of heavy weight), could be available, the Shrewsbury and Devonport mails and fast coaches may be said to have attained the best conceivable results. We had then a lull in the improvement of traffic. For some years we were content to maintain a rate of excellence that was nowhere to be met with out of England. Then came the unexpected triumph of "Puffing Billy" and his friends. Not knowing what to do with the waste high-pressure steam, the engineer turned it up the chimney, and found that, in its hasty escape, it afforded him the means of flying a mile in a minute. Steam volunteered to do more, after its actual calculated task was done, than had been asked from it in the first instance. The power of producing motion by pressure had been matter of calculation, the power of generating heat by rapid blast was an unexpected godsend. This blast was the very life of the railway.

Intermediate, to some extent, between the latest improvement of the high ways and the substitution of iron tracks for the main through roads of the country, was the introduction of water-carriage for heavy merchandise. We are not among those who consider that we have heard the last word as to canals. In the first place, long lines of this nature exist, well laid out in many cases, and have to be kept up, or to be destroyed at a considerable expense. Thus the actual cost of water carriage is the lowest required by any mode of transport. The point where the canal is at a disadvantage is speed. So long as we stick to the towing-path the rate of transit is necessarily slow. But an age which has seen the application of steam-power to an object so refractory as that of breaking up the earth over a large area—a duty that might well have been thought beyond the function of machinery—is not likely to fail in the endeavor satisfactorily to apply steam-power to canal towage, when once it appears likely to pay. In fact, the plan of what was called many years since, the "messenger propelling engine," seems likely to meet every requirement. In any case the improvements of the past 20 years have been such as to lead to the anticipation that the application of steam or other mechanically produced power to machinery of all kinds is yet only in its infancy, and that what we can now do by mechanism is but a very small part of that which mechanism is destined to effect. At present, however, we can only speak of canal transport as among the abandoned improvements of the past—one of the three great steps made by our engineers in the conduct of internal traffic—viz., good roads and good coaches, good water-carriage, and main trunk railways.

The stimulus that will be given to the railway system by linking the networks of the various great companies together in one organic whole, must cause, not only the great increase of traffic due to this facilitation, but the prosecution of what may be called the Secondary Railway System. Isolated attempts at this development have been made for some years past, with more or less success. We have had reports of the cheap construction and economical working of light railways in India, Norway, and elsewhere, that are perfectly

conclusive in the opinion of engineers. We are witnessing the attempt to introduce tramways into London, with, apparently satisfactory results in a commercial point of view, although the questions of the interference with ordinary road traffic, and of the effect likely to be produced on the rental value of the principal thoroughfares, cannot be regarded as decided. But what is desirable, and will, no doubt, follow, is, that the service of those parts of the country which are as yet only very partially benefited by the railway system, shall be regarded as a serious national object. Call them light railways, tramways, or what we like, we must have the means of reducing the running friction which forms so large a portion of the expense of land carriage placed at the disposal of the country. The important point is, that the method of effecting this object should be so decided by the best professional experience, that, when the wind of public favor sets in that direction, we should not have a repetition of the madness of 1845—every man's hand against his neighbor—for the construction of his own speculative tramway. A well-constituted railway federation, giving the weight of its sanction to the most available lines of subsidiary railway, in the first instance, may save us from this disaster. At all events, it is not easy to see what other check will be available, as Parliamentary legislation hitherto has only intensified the evils of competition.

The question naturally arises, can the control of the internal traffic of the country, if centralized, be safely intrusted to any other hands than those of the State? Out of England the answer would be simple. Roads and highways have always been regarded as the special charge of the administrative powers. Postal and military exigencies alone require the unfettered action of the Executive; and for the Postmaster-General or the Minister of War to have to apply to the Railway Director-in-Chief for the means of sending dispatches, or moving troops. could never for a moment be tolerated in a duly organized State. But it would be unsafe to make any prophecies as to England, however probable it may appear that railways will be dealt with by and by as telegraphs are now being dealt with. A country that allowed a mighty Continental empire to remain for a series of years under the rule of a trading company may well allow any commercial interest to grow, bit by bit, to Imperial proportions. Again, much of the battle as to the conveyance of mails and troops has been already fought out in detail, and in the application to the Legislature for powers to render the proposed federation not only legal but binding, opportunities would be afforded for the protection of the public interest. With the impression, then, that the ultimate form to be assumed by our railway management will be that of a department of the Government, we think there is no such certainty in the matter as to allow of any very practical inferences being drawn on the subject.

There is, however, a point of view of no small importance which is not only national, but international. Our insular position prevents us from being bound in the chain of that common interest which unites, or ought to unite, the railways of the Continent. But our interest in the proper development and management of those railways is scarcely inferior to that of the States through which they pass. Considering our connection with India, the state of the line over which the Indian mail is transmitted to Brindisi, is hardly less a matter of English interest, than the condition of the Holyhead route itself. Now there has long been a determination evinced by the directors of the French railways to throw every possible obstacle in the way of a route which shortens our journey by 60 hours, but which avoids Marseilles. The opening of the Mont Cenis Tunnel brings this matter to a crisis. The Italians have their 30 miles of railway up to the tunnel complete; the French 10 miles are all in disorder. Only an omnibus train, stopping so often and so long as to weary the patience of Job himself (if the much enduring patriarch had taken a ticket), is allowed to crawl towards the perforated barrier of the Alps. The tunnel is complete; but, if French policy can avail, it will be rendered no thoroughfare.

We require a body of men, or a duly authorized individual, to deal authoritatively with this and with similar questions, on the part of the commercial interests of this country. If left to diplomacy to settle, the dispute will unavoidably drag on for years. It is not by way of flinging a stone at our noble and patriotic

representative in France that we say so; but a minister has his hands very closely fettered when he is called upon to advocate any commercial interest, and especially when, as in the present case, peremptory settlement of the matter must be demanded, on pain of making immediate arrangements (which are perfectly feasible) to avoid France altogether for the route of the Indian mail. That despatch must and will take place from the proper point of the South Eastern Continental system of railways, namely, from the old Roman port of Brindisi. Our shortest way to this point is through the Mount Cenis Tunnel. But other routes are open to us, and the day of Marseilles, as the sailing port for India, is over. If the French will not see this—which is not unlikely—we do; and we require machinery to act nationally in consequence. It is now possible to effect a great saving in the transit of the Indian mail, and it concerns us deeply that this should be at once carried out.

There is one question which we are much surprised to find still not only unanswered, but even unasked. It is a question not, perhaps, of any great commercial importance, but of deep interest to the scientific world, and to the profession of the civil engineer. How did the two lines of the Tunnel meet? We all know that the junction was happily effected, and that the line is now complete and in working order, through the bowels of the Alps.

We offer our most sincere and hearty congratulations to our Italian *confrères*, the engineers Grattoni and Grandis; and only regret that Sommeiller died just too early to witness the triumph. But we must be excused for asking for details. What was the actual measurement—decimals, inches, feet, or yards—by which the two centre lines, started 8 miles apart, were found to differ from absolute coincidence when they met? What was the divergence in azimuth, and what was the difference in level? The more or less can hardly affect the well-earned fame of the successful engineers. But the gratitude due to their skill and tact will be increased if they furnish an accurate reply to a question which, though exclusively technical, has a deep and lively interest for the profession in this country, and will furnish a piece of valuable information in the history of the important public works of the present century.

THE STEVENS INSTITUTE OF TECHNOLOGY.

(*Continued from page* 536.)

The course of instruction to be given at the Stevens Institute of Technology, as stated by the Trustees in their "Announcement," is intended to be such an one as will "fit young men of ability for leading positions in the department of mechanical engineering and in the pursuits of scientific investigation, from which this and all the sister arts have derived and are daily deriving such incalculable benefits." it is therefore arranged with a view to afford "a thorough training in the elementary and advanced mathematics in so far as these are useful means of investigation and work, and not themselves the ends and objects of labor." It also includes very thorough courses of instruction in Physics, Chemistry, and Metallurgy, throughout which the student will be expected to do real work in the laboratories, pursuing experimental investigations bearing upon the principles taught, and in the course of which he will be directed in the field of original research.

In the workshop he will be taught the use of tools, and will be expected to spend a fixed proportion of his time in acquiring the details of workshop practice.

Languages and literature are given a deservedly important place in the college *curriculum.*

The full course is four years in length.

The first two years are properly preparatory, the student taking the usual college courses in science, with, however, a careful adaptation of their details and of the methods of instruction to the requirements of the advanced, and truly technical courses of study.

The instructors are expected to point out to their classes with scrupulous care, the important bearing of the principles of pure science upon the phenomena of every day life, and to impress upon them those

principles which become most important and useful in the succeeding years of study, by every possible means, whether of simple tuition or of practical illustration.

At the close of the first two years, the student having completed the usual elementary courses of mathematics, chemistry, physics, modern languages and literature, and of mechanical drawing, he is prepared to enter upon the advanced courses in science and for technical instruction.

In the languages, during the last two years his reading becomes to a considerable extent technical, and it is given such a direction that it may be made useful to the student in the line of the special work which he will have to do in post-graduate years.

In the chemical laboratory, the student engages, under the direction of the Professor, in the study and practice of analysis, qualitative and quantitative, and in the investigation of practically useful and important chemical problems, and in experimental investigations in some of the many promising directions that are continually presenting themselves in the practice of the engineer and in the experience of the man of science. The analysis of useful ores, and of the hundreds of materials used in the arts, detecting their impurities and their adulterations, or proving their excellence, and revealing the valuable elements in useful compounds or determining the best proportions of combination, are some of the applications made of the time spent in this department during the advanced course.

In the Physical laboratory, the student receives such an advanced course of instruction, such as is very rarely given in even the best of American colleges, and this constitutes a very important part of the general course.

He is, by a two years course of instruction in the actual use of physical apparatus and in the prosecution of experiment and research, familiarized and impressed with the physical properties and laws of matter. The instruments and methods by which those properties are revealed and by which those laws are demonstrated, are exhibited to him, and at the same time he acquires a sleight in the use of apparatus that is of great value in itself, and, also, as a mnemonical aid.

Habits of accurate observation and logical deduction acquired by such a training in precise observation and investigation, will tend to make the knowledge attained exact and ineffaceable, and the education of the mind and the hands to work together, prepares the student for similarly effective investigations in his subsequent professional life.

In pursuing this laboratory work, the student receives from the Professor an outline of the special research to be undertaken, and with it a minute description of the construction, use, and adjustment of the instruments needed in the work.

He then goes on with his work and the results of his labors are carefully preserved, and, at the proper time, if of general interest, published.

The Trustees state their willingness to extend the facilities for such work which are possessed by the Institute, to all competent investigators, upon very moderate terms, whenever important investigations are proposed to be undertaken.

Prof. Tyndall says: "Half of our book writers describe experiments which they never made, and their descriptions often lack both force and truth; no matter how clever and conscientious they may be, their written words cannot supply the place of actual observation." He might have added, "and of actual manipulation."

The students at the Stevens Institute will not be of the class referred to.

It is at the close of the second year, also, that the student is expected to be prepared to enter upon the course in Mechanical Engineering.

He first takes up the subject of Applied Mechanics, and studies the nature, uses, strength, and methods of preparation and of preservation of the materials used by the engineer. He is made familiar with the theory of machinery, and is taught the principles of tool-making and tool-using, and of design, in their application to machinery and mill work.

He is given instruction in the proportioning of cams, gearing, and other elements of machines, and is then made to design and proportion pulleys, levers, windlasses, pumps, and others of the simpler machines.

He has pointed out to him the modifications of design which become necessary in consequence of difficulties in pattern

making, moulding, forging, or finishing and fitting up the several parts of the machine.

He is made familiar, as far as possible, with the cost of stock and of labor, and is expected to calculate the amount of these items in special cases.

The Prime Movers are made the subject of study and discussion during the last year of the course, and specially careful and extended consideration is given to the principles of the steam engine and to all the details of its design, construction, cost, and management, according to the best and most recent practice.

At the close of this course the student is expected to read a thesis upon a professional subject, illustrated, where necessary, by drawings, and his success in this will have an important use in assisting the faculty to determine what success the student has met with in the endeavor to profit most fully by the instruction received in the professional course, and to whom should be offered the best of the business positions which are placed at their disposal.

The course of instruction in Drawing extends through the whole four years, and during the last two years, is intended to be a parallel course with that of Engineering, being directed in such a manner that while studying the elements of machines, the student, who has previously learned to use his instruments skilfully, may make drawing of those machines, and when studying the more complex machines and the prime movers, the student will devote his time in the drawing room to the same subject, the two courses being thus made to aid each other as far as possible.

The President of the Stevens Institute is Dr. Henry Morton, well known to the public generally as a successful lecturer, to physicists as an original investigator, and among engineers as, for a considerable time, and until recently, the editor of our esteemed contemporary, "The Journal of the Franklin Institute."

The chair of Engineering is filled by Professor R. H. Thurston, of whom the "Providence (R. I.) Journal" says, in an article descriptive of the Stevens Institute: "He acquired his practical knowledge and training here in Providence, with Messrs. Thurston, Greene & Co. and Thurston, Gardner & Co., his scientific education at Brown University, his experience in the management of steam engines and machinery here and during a ten years' service in the navy as an engineer officer, and his experience as an instructor by a five or six years' term of duty as 'A. A. Professor and Lecturer on Natural Philosophy,' at the Naval Academy."

Manufacturers are doing much to assist Prof. T. in making his course a success by contributing liberally drawings and models of their machinery.

In addition to those already named, A. S. Cameron and W. D. Andrews promise models of their pumps; Messrs. Babcock & Wilcox and Richards, Loudon & Kelly send drawings; Cooper & Hewitt offer samples of their iron and steel manufacture, and dozens of other well-known firms promise similar favors.

Prof. T. also acknowledges the kind assistance of Prof. Rankine, E. B. Martin, F. de Lesseps, and other Transatlantic friends of technical education.

Dr. A. M. Mayer, as Professor of Physics, opens the large physical laboratory above described. His long experience as an instructor, and his familiarity with the best methods of research as evinced by the success of his original investigations, published in our own journals and quoted abroad so frequently, will render him an excellent coadjutor with Professor Morton in the inauguration of this most important branch of collegiate work.

Professor Albert R. Leeds has accepted the call to the department of Chemistry, and has brought with him his cabinet of minerals, turning them over to the Institute. Prof. L. was formerly Lecturer on Chemistry and Geology before the Franklin Institute of Philadelphia, and still earlier at Haverford College, and in the Philadelphia Dental College, which institution at that time and since has achieved a very marked success.

Lieut. Col. H. A. Hascall, U. S. A., has resigned his commission and has retired from his professorship at West Point, to accept the chair of Mathematics in the Stevens Institute, and his resignation will be much regretted by his army friends and pupils, while the authorities of the Institute have equal reason to congratulate themselves on securing him in that very important department.

Col. Hascall has been prevented by ill-

ness from entering upon his duties promptly, but his place is ab'y filled by Professor R. H. Buel, lately Assistant Engineer on the Tehuantepec and Nicaraugua Ship Canal Survey, and who was formerly an officer of the U. S. Naval Engineers and an instructor in the Department of Natural and Experimental Philosophy of the Naval Academy.

Professor McCord, a graduate of Princeton, a gentleman of considerable experience as a mechanical engineer, and who has done much of his work under the eye of Captain Ericsson, is Professor of Mechanical Drawing. Professor Kroegh, formerly of Lehigh University, is Professor of Languages and French and German Literature, and Professor Wall, the able Director of the Stevens High School—the preparatory school of the Institute—takes charge of the Department of Rhetoric and English Literature.

With a large, well-designed, and substantial edifice, a carefully selected stock of apparatus, and fine corps of Professors, the STEVENS INSTITUTE OF TECHNOLOGY makes a splendid start as a pioneer School of Mechanical Engineering, and we may feel confident that the success of its graduates in the practice of their professions, whether of science or engineering, will find its limit only in that of their own industry and talent.

SCIENCE IN PLAIN ENGLISH.

By PROFESSOR CHARLES A. JOY.

From the "Journal of Applied Chemistry."

Under this heading I find in "Nature" an admirable article by William Rushton, of Queens College, Cork, which I propose to make the text of a few remarks upon the present condition of scientific education in the schools of the United States. Mr Rushton admirably epitomizes the state of things in England in the following sentence: "Some schools have admitted science on about the same terms as dancing—that is to say, they give 1 or 2 hours a week to it; or, they may even admit it on equal terms with French, but it is generally made quite subordinate, and while classics are rewarded with high honors, science receives few distinctions." We must admit that what he says of English schools applies equally well to our own. Does anybody know of a preparatory school in the United States where instruction in science is given on a systematic plan by teachers especially fitted for the work, and with well-selected apparatus and judicious text-books, and where an equal value for excellence in science is given to pupils as for mathematics or the languages? There are doubtless some such schools, but it is my misfortune never to have heard of them. The truth is, there are few teachers. The custom in this world of studying everything else but the world we live in, which has been handed down to us from our ancestors, has precluded the possibility of anybody being fitted to teach the natural sciences excepting the few who have had the energy and the means to overcome every obstacle, and to learn something; and they are so rare that they are not to be had for ordinary schools. We are now in a fair way to acquire considerable knowledge of the planet Mars, its climate and physical condition; and it may be that we shall some day be favored by a visit from an inhabitant of that distant world. The arrival of such a visitor would be rapidly heralded over the land, and he would be introduced to our best society, to the leading men of education; and as he would doubtless be possessed of an inquiring turn of mind, he would have many embarrassing questions to ask. He might address the inquiry to the gentleman on his right at the public dinner, which would be sure to be given to him, as to the composition of the crust of the earth; or he might ask what the glass windows were made of, and what form of light shone through them, or the water on the table and the air of the room might absorb his attention. If the respondent happened to be a University bred man, the chances are 10 to 1 he could not answer a single question; he would be forced to say that the study of the language of a people formerly occupying a small portion of the globe had monopolized all of his time, and prevented the acquisition of a

knowledge of any of the natural phenomena around him; he might in fact have more knowledge of Mars than of the earth. It is probable that our visitor would be slightly astonished at the ignorance of the best educated members of the community. I do not know that we are bound to prepare ourselves for the approaching visit, but the very suggestion of it ought to startle us a little out of our propriety, and make us review the course of instruction we have pursued for so many years. As long as the requirements for admission to college are left just as they are at present, all persons who expect to go to college must follow a prescribed course, or be found wanting. The teacher in a preparatory school knows that the pupil can attend only a certain number of hours, and to get up his task for admission to college nearly all this time must be devoted to classical studies. There is no time left for science, and it is not taught. This state of things has led to a violent controversy on the part of the advocates of the two systems, and the question appears to be no nearer a solution at the present time than it was many years ago. The advocates of classical training will not yield an inch of ground, and the scientists are equally firm. It is a pity that some compromise cannot be effected, as a knowledge of Latin and Greek is of great value to the scientific student, and ought not to be omitted. And as the classicists now have the colleges in their power, would it not be well for them to recommend a knowledge of language rather than of grammar, and a facility of reading generally instead of prescribing the precise number of chapters and verses? If the teacher of Chemistry, for example, were to insist upon the students studying 100 pages of Miller, 50 pages of Roscoe, two books of Gerhardt, the correspondence of Lavoisier, and the life of Berzelius, before presenting himself for examination, he would be looked upon as slightly deranged; and yet this is precisely what is done by our classical friends. A chemist can tell in half an hour whether the candidate is prepared to go on with a certain class; and he cares not how, when, or where the applicant obtained the knowledge. Not so our classical friends; they insist upon chapter and verse as if there were a charm in the prescribed number—and by so doing they do great harm to our schools. A friend of mine desired to put his son at a select school, and had a long conversation with the principal in reference to the studies he would have to pursue in order to fit him for college. The principal had the experience of 30 years in his calling, and knew precisely what was required. He produced his scheme of hours, and convinced the parent that in order to fit his son for college it would be necessary for him to devote a certain number of hours to the reading of a prescribed number of pages and verses of Latin and Greek; and to do this no deductions could be safely made. He showed that the average attendance of boys was about 6,000 hours, and by assigning to each hour its particular work, if not interrupted by accident or illness, the pupil would be able to come up to the prescribed standard. My friend tried to see if a few minutes could not be gained for a small amount of science, but the teacher, with his experience of 30 years, was inexorable, and he could not crowd in a knowledge of this world into the course of studies even edgewise. It has been sometimes said that the most ignorant members of our community are our men of education; and after looking over the scheme of studies which the victims of liberal education are obliged to follow, the paradoxical remark would almost appear to be true. It may therefore be asked what change the advocates of reform would propose? I cannot attempt to answer this question for all parties, as there is little uniformity of belief on the subject; but it may be well to state the case of a prominent party in the modern agitation. We have a large class among us who admit the culture to be derived from the study of language, and who would not on any account banish Latin and Greek from the curriculum; but they would remove that study to a later part of the course and replace it by scientific subjects. They think that those subjects which cultivate and strengthen the powers of perception, observation and judgment, should be taught first. They would instruct the youth in a knowledge of the laws of health or physiology; they would have him know something about plants, animals, minerals, and the commonest laws of chemistry and physics, so that if the pupil is compelled to leave school at an early age, he would know how to take care of mind and body, and be enabled to

turn his knowledge to some account. They would commence the study of Latin and Greek at a period when the mind is more mature, and thus avoid the enormous waste of time, the bad habits of droning over lessons, and the monopolizing character of the present system. There are so many instances of persons who commenced the study of the classics at mature years, who have excelled all others, that the advocates of postponing languages to the latter part of a boy's course appear to be justified in their claim. If the study of Latin and Greek could be commenced after the student enters college, it is believed that more real progress would be made in the four years of the college course than is effected under the present arrangement of devoting ten years of a boy's life to this study. This is the compromise that many good men advocate. They wish the preparatory schools to be wholly given up to mathematical, scientific and English studies, and to have the colleges assume the charge of the classics. Instead of devoting every hour of the preparatory course to languages, they would give the time to the sciences, and they would demand a knowledge of the general principles of science as a requisite for admission to college. This would be turning the tables entirely, and would afford scientific men a chance to try the effect of the modern education. The other side have had it all their own way for a long time, and it would appear to be no more than fair for them to let people of different views have a chance. Such a radical change as this cannot be accomplished at once. It would demand immense moral courage on the part of the trustees of a college to expose themselves to the cry of lowering the standard of study. They would have the alumni of existing institutions and the prejudices of the whole community against them, and it would require a generation before the majority would become reconciled to the new order of things. Another obstacle would also arise at the outset, and that would be the difficulty of securing competent teachers of the natural sciences. It is this obstacle that has stood in the way of the introduction of the study of science in our schools. There are far too few teachers. To surmount this difficulty in the city of New York, a normal college for females and a free college for males have been established; and scientific schools have been founded in all parts of the country. These institutions are destined to work a great revolution. As soon as they have trained a sufficient number of teachers, we shall find our public schools affording a better education than at present, and their example will have to be followed by the owners of private schools, who desire to keep up with the progress of the age. What we want is science taught in plain English, and there is every prospect of our speedily attaining the desired end.

ON THE SANITARY ADVANTAGES OF SMOOTH AND IMPERMEABLE STREET SURFACES.

By EDWIN CHADWICK, C.B.

From "Journal of the Society of Arts."

The condition of the surfaces of the streets, courts, and alleys of the metropolis formed an important topic of examination under our Metropolitan Sanitary Commission. The state of the unpaved districts; the noxious emanations from the subsoils; the absorbent surface mud; the stagnant pools containing dung and other decomposing animal and vegetable matter;—the filth collected on the person and on clothes derived from it, and taken into the habitations, powerfully affected the cleanly habits and the health of the population, especially of the children, who are always out playing upon such surfaces. In places where self-cleansing house drains and sewers have been brought into good action, and where the death rates have been reduced, but where some amount of typhoid and foul-air diseases yet lurk, they have been found to be very much confined to those streets where the surface is unpaved and badly cleansed, and the subsoil sodden with foul matter. The pernicious effects of these conditions are, as might be expected, most severe on children, from their being, by reason of their lower stature, nearer to the ema-

nations, and from their being more weakly, and thence susceptible to their influence. The sanitary condition of the then best paved streets was very bad, presenting "seas of mud" in winter, and in summer giving off "clouds of dust," which settles on the clothes, the skin, and the hair, and gets into the lungs. The worst is that the dust is generally dung dust. The experiments of Professor Tyndall go to prove that the whole of the visible particles floating in London rooms are of organic origin ; and other experiments have stated that horse-dung furnishes the greatest proportion of them. In some of the leading thoroughfares as much as a cart-load of dung was removed daily from every mile of street. In the City there were, I was informed, about one hundred loads of surface matter, chiefly dung, removed daily. To persons coming from the rural districts the streets frequently smelt like badly cleansed stable-yards.

At the first General Board of Health, in times of severe epidemic periods, we directed that the affected districts should be carefully and thoroughly surface-cleansed. This was directed to be done by jets of water thrown by engine power, or from the mains where water at high pressure was available ; but in many districts the jets, in clearing away the dung deposits from the interstices of the paving, often also washed away or tore out much of the supports of the large stones, and even, where they were firmly jointed, left much objectionable surface water and evaporating moisture. The only remedy available in some excrement-sodden districts was to cover the street surfaces over, for the time, with fresh mould or soil, which, when it was done, made the people feel, as they said, as if they were living in another atmosphere.

It resulted from our examination that, by some better mode of paving, which we hoped might be obtained—than that of large stones put down to resist the shock of heavy carriages, which again entails the construction of heavy carriages to withstand the shock of the large stones—and by lowering the gradients, and by the introduction of tramways at some points, half the usual horse power might be saved —a saving of great importance in itself in the economy of traction and of intercommunication ; but, in our view, of peculiar sanitary importance as a diminution of half the horse-dung and its noxious evaporation, and the injury of the dust and dirt, and a reduction of the expense of the surface cleansing of the streets.

I certainly expect that the saving of horse power, from the paving with the new material, of peculiar hardness, as yet unsurpassed, and, as far as I have seen, unequalled, by anything of the kind—the Val de Travers asphalt—will be more than one-half of that power, and consequently a saving of more than half the dirt and dung in the streets, and that this pavement will nearly equal the tramways in this respect for public vehicles, whilst it will exceed tramways in general convenience, especially for all sorts of private carriages. Sir Joseph Whitworth, who has studied street economy and the means of street cleansing, and who is much struck with the new material, tells me that he anticipates that when extensively adopted, it will make way for the hot-air engine, with india-rubber tyres. A colleague of mine, of the Institute of France, who for the last 10 years has ridden over a street paved with the Val de Travers asphalt in Paris, speaks of the great comfort in riding over it. The horses on becoming accustomed to the tread, he says, do not certainly slip more, or so much, and when they fall do not tear their knees as on the old pavements.

One advantage of gravel soils is the rapid discharge of surface water, and immediate dryness after rainfalls. This advantage is possessed in a high degree by the impervious and even asphalt surface.

There is one peculiar evil attendant on the old systems, which is the noise, the rattle, and the vibration of the traffic over them, to which strong people become accustomed, and do not mind, but from which weakly and ailing people suffer very much, being sometimes obliged to leave town to avoid it. The removal of the sick over these paved roads is often attended with considerable danger from the rolling and shaking. At our General Board of Health, it was strongly represented that great injury, often fatal, was inflicted by the removal of some large classes of sick in common cabs, or in other common conveyances, over paved roads. Exhortations were prepared for popular circulation, that, on the occurrence of accidents in the

streets, attended by the fracture of limbs, it is of the greatest importance that patients should not be put into any common conveyance for their removal, but should be allowed to remain where they fall until a surgeon can be brought to direct special and safe means of removal by stretchers. In relation to the action of granite pavements on healthy persons, a professional friend declares that the loss of what he calls "brain force," from the vibration and disturbance of the nervous system in much riding over the old carriage pavements, is much greater than would be imagined. We know that for ladies of the well-to-do class, it is found necessary at times to spread straw over the street, to prevent the vibration, and deaden the sound of carriages. With a pavement of this very remarkable new substance, which gives, with great tenacity, a sort of elastic surface—hard and inodorous alike in summer and winter—it is very much as if tan were always laid down before all the houses of a whole line of street. Tradesmen in Cheapside testify, as one characteristic of it, that without shutting their shop doors, they can now hear their customers, and can make themselves heard by them without shouting, as heretofore, to overcome the noise of the carriages over the granite pavement. Those living in such streets can now keep their windows open with little annoyance either from noise or dust.

The macadam roads, in cities of great traffic, may be said to be huge stone mills for grinding granite dust. Some notion of the extent of the work done in this way in the metropolis may be formed from the fact that there are annually imported, and used there, 650,000 tons of granite, of which it is estimated that about 100 tons are imported in cubes, and that the rest is used as macadam. In addition to this material, large quantities of flint, and also other stones imported as ballast, are used. In Birmingham, 50,000 tons of granite are put on the roads every year. Every year, therefore, so many tons of granite are ground, in dry weather, into dust with dung, which the winds carry about, and in wet weather into mud. The wear of the macadam roads is from 1 to 4 in. or more of granite annually. Westminster-bridge, it is stated, requires annually a coating of at least $5\frac{1}{2}$ in. of the very best granite that can be got. The wear of any smooth road, by reason of the very smoothness, is comparatively inconsiderable, an example of which, I am informed, may be given, though of a street of secondary traffic, compared with our chief thoroughfares, the Rue Bergere, in Paris, where the result was observed. The street was laid with 2 in. of Val de Travers asphalt in 1854, which was lifted in 1869 when it was found to be reduced to $1\frac{3}{8}$ in., but chiefly by compression, for it had, during the 15 years, lost only 5 per cent. in weight. I am informed that similar results have been obtained in Threadneedle street, for the time the new pavement has been down there.

We found that those granite pavements very injuriously affected the working of the sewers. When the granite dust is washed by rain into the sewers, it often forms an indurated surface, only to be loosened by the pick, and to be removed at much trouble and expense. This sometimes occurred, even with tubular glazed pipe sewers. To obviate this evil, we had traps carefully constructed at the mouths of the gulley shoots to arrest the granite detritus, for which, however, in times of storm or heavy rain, they proved to be insufficient.

When the new granite or flint material for macadam is first laid down, it is a cruelty to horses, and a barbarism as respects carriages and carts, to impose upon them the labor of crushing it. The steam-roller is a relief to them, and an economy in getting a somewhat better surface, though still, to some extent, a permeable one for dung. But this implement, it is now found, aggravates waste and evil of another sort, produced by the vibration from heavy traffic. One great inconvenience in those streets is the frequent breaking up of the pavement for the repair of gas and water pipes. I found from my own inquiries that the leakage of those pipes was very much proportioned to the heaviness of traffic, and was inconsiderable in the by-streets and districts of little traffic, the vibration of the heavy traffic perpetually shaking the lines of pipes and loosening their joints. The escape of gas, besides being a waste—which in some districts was stated to amount to as much as 30 per cent.— was attended by sanitary evil in the pollution of the air, and even in some cases of the drinking water. So great in some districts was the

saturation of the subsoil with gas, that, where the water supply is on the intermittent system, and the pipes are alternately full and empty, the water-pipes were often filled with gas sucked in from the substratum through the loosened joints when the water was drawn out of the pipes. Mr. Milne, the engineer of the New River Company, to demonstrate this condition to me, and show that to the water were frequently ascribed impurities which did not belong to its original and proper quality, took me early in the morning to the new road, and applied a match to the tops of water-plugs, and lighted the gas that escaped from them. Instances were stated of people, on going with candles to the taps in houses to draw water, being surprised by a blaze of gas from them.

The operation of the new steam-rollers, whilst it relieves horses, carriages, and ordinary vehicles from the labor of crushing and forcing down granite, and is in other respects economical for the macadam roads, is productive of injury and waste by a yet more powerful vibrating action than the ordinary traffic, and by a greater disturbance and rupture of the system of pipes beneath the surface. Some of these rollers weigh as much as 30 tons each. I am informed that the gas and water companies in London and in the provincial cities have had serious cause to complain of the use of these rollers, which bring to bear the weight of some 20 or 30 one-horse loads upon one fulcrum, and have fractured large pipes deeply laid, and have also injured the house connections.

In proposing the system of combined back drainage, that is, of carrying water-pipes as well as drains and branch sewers at the backs of lines of houses, instead of in the streets along the fronts, I calculated that, besides saving the expense and inconvenience of carrying drains and pipes under the lower floors of houses, the measure would reduce the evil of the loosening and breaking of house service-pipes, as well as the mains, by removing a large proportion of them from the direct action of the heavy traffic over the granite pavements in the streets.

There can, I think, be no doubt that the indirect economies will be greater than the direct economies from the new principle of covering the streets with even and yet hard surfaces.* One indirect economy will be the reduction of the weight of the vehicles necessary for the paved roads, and thence a reduction of the wear of the roads.

Amidst these economies are to be regarded the reduction of pain as well as the economy of horse-power. I have received from my esteemed correspondent, Dr. Edward Jervis, of Massachusetts, a paper entitled "Our Dumb Animals," published by a new society started there, on the principle of our Society for the Prevention of Cruelty to Animals. They say: "We want to show the people of this country the abuses to which animals are now subjected, and that those abuses affect not only the well-being of the animals and of the public health, but also the tone of public morals, inasmuch as cruelty to dumb creatures begets cruelty to creatures that are not dumb. Our aim is to educate all, and particularly children, to a higher humanity, and to inspire a reverence for the great Creator of all these wonderful forms of animal life, and a more profound consciousness of our duty in regard to them." In this elevated spirit they advert to the Nicholson pavement as against cobble stones. I have seen no account of the construction of this Nicholson pavement. I am assured, however, that as at Paris, on a close comparison with other long tried means, the Val de Travers pavement is now being actively taken up in New York. But I cite the account as corroborative of the principle of a smooth as compared with a rough pavement, and for the Society's discrimination of the elements of humanity with those of economy involved in the application of the principle by whatsoever means. They state that by the new smooth pavement:

"Streets which once had but little else but light pleasure carriages coursing through them, are now filled from morning to evening with heavily-loaded drays, and carts, and carriages of all kinds. The ex-

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* In respect to the interior of the metropolis, Sir Christopher Wren's admirable plan for the rebuilding of the city, which is still good as a study, provided for direct lines and for level street surfaces. He would have prevented Holborn-hill and Ludgate-hill. I got Mr Butler Williams, when principal engineer of the College of Civil Engineers, to ascertain by survey how much had been lost by deviations from Sir Christopher's plan—lost by increased gradients as well as by increased distances; when it was proved that the loss of horse-power, and of time on those two hills alone, would almost pay for the reconstruction of the streets and the restoration of the plan of the architect of St. Paul's.

planation is that the teamsters and cabmen have found out that they can drag their heavy loads over the smooth Nicholson pavement with half the wear and tear of team and cart that is expended on the cobble-stone pavement; and so, very naturally and reasonably select those streets which have the smoothest wheel-ways.

"And why should they not? The life of a first-class coach in Boston streets, for example, is diminishing nearly 50 per cent. by the rough cobble over which it is banged from day to day. And the life of all sorts of carriages, carts, and wagons is probably diminished proportionately. The wear of horses, too, is, no doubt, somewhat in the same proportion. The sprung knees and unsound hoofs of our city horses are a continual protest against cobble stone. How can a poor horse be expected to do half his appropriate work, or live out half his appointed days, who is rarely allowed a chance to put his foot down flat on the road he is travelling, but must step and pull over a series of round stones, which afford no firm footing, and which jerk and wrench the carriage in every direction, every motion of which is an unnatural and unreasonable and injuring strain on the faithful animal who is tugging along his heavy load?

"A first-class livery coach, which costs the stable-keeper $1,600 or $1,800, will last as such about half-a-dozen years only in Boston streets. It is then sold for about what has been expended on it in repairs during the time it has been in service; and so the coach is in fact sunk and lost in the course of about 5 or 6 years. And it is very much so with every sort of carriage which is used in our city. Not that they wear out equally quick, but that their life, if we may so speak, is proportionally shortened, and so it is, too, with the poor horses.

"Now let those who have the making and paving of our streets bear these facts in mind, and they will see that true economy, as well as comfort, demands that our streets should be made just as smooth as is compatible with durability, and that cobble-stone pavements should be banished as fast as possible from our city limits."

It is confidently anticipated that the improvement of the road surfaces will lead to the improvement of the shoeing of horses.

The Corporation of the City of London have rendered a public service by the trial of the new material in streets of such tremendous traffic as those where they have had it laid down, but they would render the example more complete by having the surface washed, in certain weathers, by the jet. The municipal authorities of the cities where they have command of a constant supply of water at high-pressure who did this would have the most complete sanitary street surface yet known. From some trials I got made at the first consolidated Commission of Sewers, it appeared that the cost of cleansing the roadway of the Strand by the jet daily would not be more than threepence per house per week. One of the methods then brought forward, of a hose with a movable carrier, for cleansing the streets by jet, has been adopted in Paris, with great success, on the asphalt pavement. If a suitable pavement were provided, we estimated that the streets of the whole of the metropolis might be kept as clean as a gentleman's court-yard at a rate of a halfpenny per week per head of the population—a rate that would effect a great economy of clothes, and of washing, and merchandise. I deem the conditions that require sweepers of street crossings to be a mere barbarism, being clear evidence of the excessive dirtiness of the general surface.

For these reasons chiefly I have taken a personal interest in this Val de Travers pavement, as realizing more than we expect in the amendment of town pavement. It were to be wished that the material were more abundant, that it might be obtained cheaper. As it is, however, although there appears to be no economy in the first construction, as compared with granite, there are evidently very large economies in its use—economies in cleanliness and health, in the preservation of clothes and furniture, in goods, in horse-power, and carriages.

The lower districts occupied by the many—the wage-classes—require a special attention and consideration which they have not yet received. In some of these districts, in the manufacturing towns, a missionary visitor may observe in a dirty lane or unpaved alley, the steps of one house nicely cleaned and pipe-clayed. That is a house occupied by new comers, a young married couple, who have been

brought there from the rural districts by the inducement of high wages at the manufactory, and they could get no other house near the work. On repeating his visit some time after, the visitor will find that the distinction of the clean steps, and also of the clean floor, has disappeared. The housewife has given up the contest with the surrounding filth from the muddy, unpaved place, and the children, in their rural home once cleanly, have become almost as dirty as the house-floor. She bewails the fact that the labor of trying to keep them clean is in vain; they will go out to play, and roll themselves in the mud. Then, being always so dirty, she is ashamed to send them to school. To withstand the depressing influence of the damp and the filth of the place drink comes in, and so all are lowered to the surrounding filth, and, with higher wages, they sink into a lower physical and moral condition.

Now, it is to be maintained, as a duty of the local authorities to provide such paving and cleanly surface conditions in the poorer districts, that there will be no mud for the children to roll in, or to make "mud pies" of, if they would. It is for the local authorities, and in their default—the default, commonly, of low landlords—it is for the central authority so far as to make the population clean—as may be done by cleanly surrounding surface pavement. Of course, a special economy is to be consulted for such work, and is available for those districts where there is little quick carriage or horse traffic, and where the same peculiarly hard road-surface is, therefore, not needed. It is to be hoped that a smooth, non-absorbent, and washable surface may be got at cheap rates by the use of General Scott's "celenite," or some of the concretes, at least for foot-paths and for court-yards. I had intended to propose that these concretes, Portland and others, should be tested. I myself have a fancy for one form of title with a rabetted joint for foot pavements, which I wish to see tried. The cheaper gas-tar asphalts have some merits, but unless they are very well made they soften and smell offensively under summer heats. I am informed of examples in Germany of the use of a good smooth tar concrete for paving of play-grounds of children's institutions. Indeed, I know of one institution in the metropolis where a saving of one-half the shoe-leather was experienced after an improvement of the surface, and the cost of shoes is a very large proportion of the cost of clothing to the working classes. A general economy of shoe-leather to the bulk of the population is to be taken into account as attendant upon an improved surface pavement. The sanitary economy in childhood from the prevention of noxious subsoil emanations, as well as surface emanations from damp, and filth, and dust, will be of itself very considerable.

The economies specified are, however, much frustrated by carrying out the Val de Travers pavement in isolated patches; nor is justice done to the material in respect to cleanliness, while it is subjected to the dirt of side streets and old pavements; nor indeed are the horses fairly dealt with in being suddenly pulled up and made to change their action for short distances. It is obvious that, if the concert of different jurisdictions be impracticable, unity of administration will have to be sought, for the attainment of the benefits available to the public from the improvement.

Unfortunately for the population of the metropolis, and of some others of our cities, the local administration itself is yet retained very much in patches. Even for one line through the metropolis, the action of seven vestries would be needed. In some places we found that streets were divided longitudinally—one longitudinal half being paved and repaired by one parish at one time, and the other half by another parish at another time. The longitudinal halves, too, were cleansed by halves, often by the scavengers sweeping the dirt from one parish into the other. We proposed, to remedy this state of things by a provision that the paving should, go with the drainage jurisdiction, and should comprehend the entire metropolitan area, including the suburbs. It is only on the complete scale of a city and suburbs that the recited economy of horse-power can be achieved. The horse-traction may be reduced by more than one-half on a particular line, but beyond it, and for the unimproved suburbs, the double horse-power will still be needed. As it is, however, the shopkeepers of Cheapside and other streets declare that they are satisfied even with the partial improvement, and better cleansing surface for themselves. It is stated that some

of the vestries amongst whom the main thoroughfares are divided, whilst admitting the demonstrations of impovement which are not to be withstood, state they will wait until their present granite pavements are worn out, or until their contracts for the maintenance and renewals of the objectionable conditions are expired. Meanwhile, by this apparent saving real waste is maintained, excessive filth is being maintained, shop goods being spoiled, discomforts inflicted, and health deteriorated.

With the new available materials, the professors of sanitary science and economical science may put these questions to urban populations :—

Will you obey the command, "Wash and be clean?"

Will you pave so as to enable you to do so?

Will you pay for good paving and cleansing, to save the direct expense of filth in clothes and extra costs of washing?

Will you pay for good paving, to save more than half the expenses of horses and carriages and the costs of transit?

Will you pay, in good paving and cleansing, to reduce the greater expense of the filth diseases?

I will only add that, in the investigations to which I have referred, one large sanitary policy was kept in view, that by the measures we proposed for facilitating and cheapening intercommunication, which we were prepared to recommend should be done to the extremities of the suburban relations, the evils of internal overcrowding would be reduced. For the removal of the well-to-do classes to suburban residences extends and cheapens house accommodation to the urban population. If it were possible to drive back the suburban population upon the city, where they have their daily business, or upon the interior of the metropolis, and pile story upon story for their reception, the effect would probably be, in the existing conditions, a double death-rate. In the interests of the interior population, we were prepared to recommend the radiation of public tramways to the extreme of the civic external daily relations. But tramways provide chiefly for one class of society, not for another, the higher class of villa residents, including medical men, to whom it were desirable to provide means of doing with one horse what they must now do with two, as also for much goods traffic and retail distribution. Unfortunately, these economies and any complete civic administrative policy must wait for the advance of superior legislative principles. Time will vindicate them.

The time will come when a local administration will be tested, especially in the lower districts, by the smell of a place and by the look of the people inhabiting it.

LARGE CASTINGS.

From "The Engineer."

Were we to judge solely from the fact that cast iron has but a very limited range in the field of engineering construction, it might be fairly presumed that the difficulty of insuring sound and reliable specimens of this material increases commensurately with the dimensions allotted to them. It will be seen as we proceed with the subject that there is not necessarily any relation between mere size and the other desirable features which should belong to castings of a superior quality. A very great deal depends upon the purpose to which the casting is to be applied. In some instances it may be of a favorable and in others of an unfavorable character. In the case of a bridge the arch form is unquestionably that which is the best adapted for the employment of cast iron, although this material has been extensively employed for horizontal beams. In the early days of railways, horizontal cast-iron girders trussed with wrought-iron rods, were constructed of spans nearly 100 ft. in length; but the failures which attended this vicious method of bridge building speedily and deservedly brought it to a termination. Although the difficulty of turning out large castings is well known, yet it is not probably this obstacle which has actually prevented cast iron being more extensively employed than it has been. So far as cast-iron arches are concerned, the impediments which are insep-

arable from that particular form, such as the headway requisite, and other conditions dependent upon local contingencies, have virtually imposed a limit to the use of the material. It may be worth while to inquire into one or two of the causes which render the casting of large masses of iron so liable to uncertainty and unsoundness.

Since it is not the actual dimensions, or what is tantamount, the weight of the casting, that puts a limit to the employment of cast iron, the cause of the restricted use of it must be sought for elsewhere. While it is true that the mere weight of a mass of cast iron is no obstacle to its manufacture, yet when a very heavy weight is attended by disadvantages with respect to form and subsequent duty, it exercises a very important influence.

The simplest form in which a casting can present itself is one in which the metal is all in one mass, in which there is no special extension of surface, but the whole material is a solid agglomeration. Such an example is to be found in an anvil block or a cannon ball. In a word, the difficulty of producing in the foundry a sound casting depends upon the ratio between its superficial area and its solid contents. It is, of course, understood that a minimum weight obtains in all cases, and this brings us to another consideration, which in reality is the bar to the manufacture of all very large castings in which the solid contents are small compared with the superficial dimensions. The question turns upon the possibility of producing the casting at one running from the cupola, or any number of simultaneous runnings. Obviously, it is of no consequence to allow an interval of half an hour, or even an hour, to elapse between the consecutive running of the metal in a large anvil block which will take many days before it becomes cool. The successive runnings incorporate easily with one another, because the mass long remains fluid, each running bringing with it an accession of temperature. Moreover, to go a little further, the duty that a casting of this description has to fulfil, is one which calls into play only its weight and *vis inertiæ.* There is, as compared with its mass, little or no strain brought upon it, and its resistance is of the most passive character. Analogically, it is a pure exhibition of brute strength, and nothing else.

Passing on to a form of casting in which the mass of metal is combined with a scientific distribution of it, we come to the girder, which has been already mentioned as constituting a prominent type of construction in the early days of railways. The theory of the cast-iron girder, and the determination of the strains which affect it under given conditions of loading, are as well known as in the case of its fellow composed of wrought iron; yet, in practice, the sphere of action of the latter is nearly 10 times that of the former. In comparing the two classes of construction, it must not be forgotten that they are both subject to the same character of strains under ordinary conditions; they are subjected to strains of compression and tension, those of a compressive nature affecting the upper flanges, and those of a tensile the lower. The limit of the action of these strains is accurately defined by the neutral line, or, as it is frequently called, the neutral axis of the beam. But while the two descriptions of structure are equally affected, their separate resisting powers are very different. Wrought iron has a ratio of compressive to tensile resistance of about 4 to 5, while that of cast iron is as 7 to 1, nearly. In small examples the upper and lower flanges of a wrought-iron girder are usually made equal in sectional area, as there is nothing gained in attempting to adhere too closely to theory. The flanges of the cast-iron girder, on the contrary, are widely dissimilar in area, the lower being about 7 times that of the upper. Manifestly, when a large cast-iron girder of the form known as the Hodgkinson girder is manufactured, the rate of cooling of the 2 flanges and the web must be very different, and care must be taken to provide for any contingency that might possibly result in consequence. An inequality in the rate of cooling signifies an inequality in the rate of contraction, and it is probable that in many instances a girder or other example of the cast-iron type of construction may, from this cause, be subjected to an initial strain which is never anticipated. In addition to this danger, there are numerous others to be guarded against, such as air-holes, bubbles, cracks, and various defects, the nature of which has been admirably explained by Mallet, and there-

fore requires no special consideration at our hands.

Of the different specimens of castings, cylinders for bridge piers and columns are undoubtedly those which are the most favorably situated so far as the material itself is concerned. If properly and truly bedded, they are acted upon by no other force than that of a direct vertical pressure. It might be inferred from this that it would be easy to cast them of very large dimensions, but a little reflection will point out that they are, from what has been already stated, by no means well suited for being manufactured in single castings. The proportions between the solid contents and the superficial dimensions of a cast-iron cylinder of 10 ft. or 12 ft. in diameter, and 1 in. or $1\frac{1}{4}$ in. in thickness, is just the very reverse of what it should be to constitute the running of a large casting in that form an easy matter. The danger of successive runnings is that in the interval which must elapse between the meltings in the cupola, the metal already run into the mould has partially cooled, and perhaps solidified also to some extent. Instead, therefore, of the whole casting being one homogeneous mass, it may be split up, as it were, into as many distinct sections as there were successive meltings in the cupola. It is quite possible that there might be absolutely no cohesion or agglomeration of the metal at the places where the different supplies were poured in; in fact, the cylinder might have a number of "straight joints" all round it, supposing it to consist of a single ring. It is evidently unsafe to cast any single portion of a cylinder of such a size as will necessitate intervals of cooling during the process of running the metal into the mould. The contents of different cupolas or air furnaces, must be made available for one and the same casting, and the operation must be continuous.

There is no question but that engineers are beginning to recognize that large span bridges, gigantic roofs, and enormously heavy castings, are very bad economy, and should be resorted to only when there are no other means of accomplishing the desired object. Mere size is not and never was the highest criterion of engineering ability on the part of the designer, and the history of the Great Western Railway is a lamentable instance of the practical ill-success of the adoption of such a standard. It is always preferable to avoid taxing the resources of the foundry and the workshops beyond their legitimate means. When no other method of affecting an object is available, an ingenious *tour de force* is very commendable, and a judicious departure from the beaten track completely justifiable; but when the necessity does not exist, there is no excuse for incurring the risk, and should accidents occur there is the less excuse for them.

NEW EARTHWORK TABLES.

By W. B. Ross, C. E.

The number of works and articles which have appeared recently on the subject of earthwork computation may be taken as evidence of the general desire for something less tedious than the methods hitherto employed. The tables here described are simple and universal in their application, being in the main merely a contraction of the usual calculation.

These tables are intended to give the quantity of material in railroad cuttings and embankments from the usual data in an engineer's field book, which are—

1. The centre cut or fill, or the distance of the grade above or below the ground at the centre stake.

2. The horizontal distance of the left side stake from the centre stake.

3. The horizontal distance of the right side stake from the centre stake.

Sometimes the heights of the side stakes above or below grade are given, and when the ground is broken the distances out and heights of one or more additional points are also noted.

By use of the tables the calculation of the number of cubic yards contained between two sections 100 ft. apart is much shortened, when, as is usually the case, the sections are regular, that is, when the surface of the ground from the centre to each side stake can be considered a straight line. There is only one method of calculating the cubic contents of a prismoid, or figure with two parallel faces connected by straight lines, and that is by the prismoi-

dal rule. The divisions or sections of railroad cuttings and embankments are always considered prismoids, and their contents can only be obtained by using the rule:

"Add together the areas of the two parallel sections and four times the area of the section half way between them and parallel to both; multiply by the perpendicular distance between the end sections and divide by six."

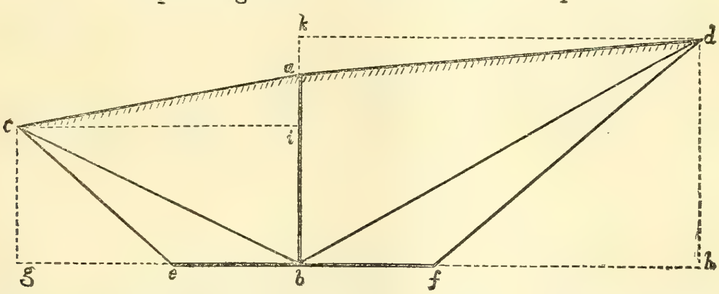
There is a great deal of labor in applying this rule to the calculation of quantities in excavations and embankments, for the area of each of the end sections must be found by dividing it into triangles, for which purpose, and as a record of the work, it is usually drawn upon paper.

The middle section is found by adding together the corresponding lines of the end sections, 2 and 2, and dividing each sum by 2 for the corresponding sides of the new section, and its area is found in the same manner as in the other sections. The distance between the end sections is usually 100 ft., which simplifies the multiplications; but as contractors are accustomed to bid for work in cubic yards, it is necessary to reduce the contents in cubic feet to cubic yards, which imposes the additional labor of dividing by 27.

In the tables this tedious process is much shortened, in the case of regular sections, by performing as many of the operations as possible at once and by use of the tabular form.

HOW THE TABLES ARE MADE.

The simplest way to calculate the area of the regular section a, d, f, e, c, is by dividing it into four triangles by means of the lines bc and bd. Then the area of the section is equal to the sum of the



areas of the triangles abc, abd, bec, and bdf. These areas are

1st. $abc = \frac{1}{2}ab \times ci$.
2d. $abd = \frac{1}{2}ab \times kd$.
3d. $bec = \frac{1}{2}eb \times cg$.
4th. $bdf = \frac{1}{2}bf \times dh$.

The sum of the areas of the first two triangles $= \frac{1}{2}ab\,(ci + kd)$, equal to $\frac{1}{2}ab \times gh$, since $ci + kd = gh$.

In the last two triangles, $cg = r \times ge$ and $dh = r \times fh$, r being the ratio of the slope, that is, 1, $\frac{2}{3}$, or $\frac{1}{2}$; where the slope is 1 to 1, $1\frac{1}{2}$ to 1, or 2 to 1, then the sum of their areas is, since $eb = bf$,

$$= \frac{1}{2}eb\,(cg + dh)$$
$$= \frac{1}{2}eb\,(r \times ge + r \times fh)$$
$$= \frac{1}{2}r \times eb \times (ge + fh)$$
$$= \frac{r \times eb \times (gh - 2eb)}{2}$$

since $ge + fh = gh - 2eb$.

Now, the area of the section consists of two parts, the sum of areas of the first two triangles

$$= ab \times \frac{gh}{2}$$

and of the second two triangles

$$= \frac{r \times eb \times (gh - 2eb)}{2}.$$

Suppose we make a table for computing areas consisting of two numbers for each value of gh or the extreme width of the section; let one be $\frac{gh}{2}$, which multiplied by ab will give the first part of the area and the other be the second part. The areas of sections could be easily and rapidly found from this table, but our object is beyond areas.

Having found the areas of the end sections and four times that of the middle section, we add them together, divide by 6, multiply by 100 and divide by 27, to find the contents in cubic yards by the prismoidal rule. Now these last two operations could be entirely avoided if each number in the table were multiplied by 100 and divided by 27 instead.

This being done, all that will be necessary to obtain the true quantity of material between two sections, will be to find from the width and end height of each section, the quantity from the table and four times the like quantity for the middle section, add them together and divide by 6.

(SPECIMEN TABLE.) BASE 18. SLOPES 1 TO 1.

Tenths. ☞	0		1		2		3		4	
Feet.	Cen. Cut. Multiplier	Add.	Cen. Cut. Multiplier	Add.	Cen. Cut. Multiplier	Add.	Cen. Cut. Multiplier	Add.	Cen. Cut. Multiplier	Add.
18.....	16.67		16.76	.8	16.85	1.7	16.94	2.5	17.03	3.3
19.....	17.59	8.3	17.68	9.2	17.77	10.0	17.86	10.8	17.96	11.7
20....	18.52	16.7	18.61	17.5	18.70	18.3	18.80	19.2	18.89	20.0
21.....	19.44	25.0	19.53	25.8	19.62	26.7	19.72	27.5	19.81	28.3
22.....	20.37	33.3	20.46	34.2	20.55	35.0	20.65	35.8	20.74	36.7
23.....	21.30	41.7	21.39	42.5	21.48	43.3	21.58	44.2	21.67	45.0
24.....	22.22	50.0	22.31	50.8	22.40	51.7	22.50	52.5	22.59	53.3
25.....	23.15	58.3	23.24	59.2	23.33	60.0	23.43	60.8	23.52	61.7
26.....	24.07	66.7	24.16	67.5	24.25	68.3	24.35	69.2	24.44	70.0
27.....	25.00	75.0	25.09	75.8	25.18	76.7	25.28	77.5	25.37	78.3
28.....	25.92	83.3	26.01	84.2	26.10	85.0	26.20	85.8	26.29	86.7
29.....	26.85	91.7	26.95	92.5	27.04	93.3	27.14	94.2	27.23	95.0
30.....	27.78	100.0	27.87	100.8	27.96	101.7	28.06	102.5	28.15	103.3
31....	28.70	108.3	28.79	109.2	28.88	110.0	28.98	110.8	29.07	111.7
32.....	29.63	116.7	29.72	117.5	29.81	118.3	29.91	119.2	30.00	120.0
33.....	30.56	125.0	30.65	125.8	30.74	126.7	30.84	127.5	30.93	128.3
34.....	31.48	133.3	31.57	134.2	31.66	135.0	31.76	135.8	31.85	136.7
35....	32.41	141.7	32.50	142.5	32.59	143.3	32.69	144.2	32.78	145.0
36.....	33.33	150.0	33.42	150.8	33.51	151.7	33.61	152.5	33.70	153.3
37....	34.26	158.3	34.35	159.2	34.44	160.0	34.54	160.8	34.63	161.7
38.....	35.19	166.7	35.28	167.5	35.37	168.3	35.46	169.2	35.56	170.0
39.....	36.11	175.0	36.20	175.8	36.29	176.7	36.39	177.5	36.48	178.3
40.....	37.04	183.3	37.13	184.2	37.22	185.0	37.32	185.8	37.41	186.7
41.....	37.96	191.7	38.06	192.5	38.15	193.3	38.25	194.2	38.44	195.0
42.....	38.89	200.0	38.98	200.8	39.07	201.7	39.17	202.5	39.26	203.3
43....	39.82	208.3	39.91	209.2	40.00	210.0	40.10	210.8	40.19	211.7
44.....	40.74	216.7	40.83	217.5	40.92	218.3	41.02	219.2	41.11	220.0
45.....	41.67	225.0	41.76	225.8	41.85	226.7	41.95	227.5	42.04	228.3
46.....	42.59	233.3	42.68	234.2	42.77	235.0	42.87	235.8	42.96	236.7
47.....	43.52	241.7	43.61	242.5	43.70	243.3	43.80	244.2	43.89	245.0
48...	44.44	250.0	44.53	250.8	44.62	251.7	44.72	252.5	44.81	253.3
49.....	45.37	258.3	45.46	259.2	45.55	260.0	45.65	260.8	45.74	261.7
50....	46.30	266.7	46.39	267.5	46.48	268.3	46.58	269.2	46.67	270.0

BASE 18. SLOPES 1 TO 1.

5		6		7		8		9		TENTHS.
CEN. CUT. MULTIPLIER	ADD.	CEN. CUT. MULTIPLIER	ADD.	CEN. CUT. MULTIPLIER	ADD.	CEN. CUT. MULTIPLIER	ADD.	CEN. CUT. MULTIPLIER	ADD.	FEET.
17.13	4 2	17.22	5.0	17 31	5.8	17.41	6.7	17 50	7.5	 18
18.05	12.5	18.14	13.3	18.23	14 2	18.33	15.0	18 42	15.8	19
18.98	20 8	19.07	21.7	19.16	22.5	19.26	23.3	19.35	24.2	20
19.90	29.2	19.99	30 0	20.08	30.8	20.18	31.7	20.27	32.5	21
20.83	37.5	20.92	38.3	21.01	39 2	21.11	40.0	21.20	40.8	22
21.76	45 8	21.85	46.7	21.94	47.5	22.04	48.3	22.13	49.2	23
22.68	54.2	22.77	55.0	22.86	55.8	22.96	56.7	23.05	57.5	... .24
23.61	62.5	23.70	63 3	23.79	64.2	23.89	65.0	23.98	65.8	25
24.53	70.8	24.62	71.7	24.71	72.5	24 81	73.3	24.90	74.2	26
25 46	79 2	25.55	80.0	25.64	80.8	25.74	81.7	25.83	82.5	27
26.39	87.5	26.47	88.3	26 56	89.2	26.66	90 0	26.75	90.8	28
27.32	95.8	27.41	96.7	27.50	97.5	27.60	98.3	27.69	99.2	29
28.24	104.2	28.33	105.0	28.42	105.8	28.52	106.7	28.61	107.5	30
29.16	112 5	29.35	113.3	29.34	114.2	29.44	115 0	29 53	115 8	31
30 09	120.8	30.18	121.7	30.27	122.5	30 37	123 3	30 46	124 2	32
31.02	129.2	31 11	130.0	31 20	130.8	31 30	131.7	31.39	132 5	33
31.94	137.5	32.03	138.3	32.12	139 2	32 22	140 0	32.31	140.8	34
32.87	145.8	32.96	146.7	33.07	147.5	33.15	148.3	33.24	149.2	35
33.79	154 2	33.88	155 0	33 97	155.8	34.07	156.7	34.16	157.5	36
34.72	162.5	34.81	163.3	34 90	164.2	35 00	165.0	35.09	165 8	37
35.65	170.8	35.74	171.7	35.83	172 5	35.93	173 3	36.02	174.2	38
36.57	179.2	36.66	180.0	36.75	180.8	36.85	181.7	36 94	182.5	39
37.50	887.5	37.59	188.3	37.68	189.2	37.78	190.0	37.87	190.8	40
38.43	195.8	38.52	196.7	38 61	197.5	38.71	198.3	38.80	199.2	41
39.35	204 2	39.44	205.0	39.53	205.8	39.63	206.7	39.72	207.5	42
40.28	212.5	40.57	213.3	40.46	214 2	40 56	215.0	40 65	215.8	43
41.20	220.8	41.29	221.7	41.38	222.5	41.48	223.3	41.57	224.2	44
42 13	229.2	42 22	230.0	42.31	230.8	42.41	231.7	42.50	232.5	45
43.05	237.5	43.14	238.3	43 23	239.2	43.33	240.0	43 42	240.8	... .46
43 98	245 8	44.07	246 7	44.16	247 5	44.26	248.3	44 35	249.2	47
44.90	254.2	44 99	255 0	45.08	255.8	45.18	256.7	45.27	257.5	48
45.83	262.5	45.92	263.3	46.01	264.2	46.11	265.0	46.20	265.8	49
46.76	270.8	46.85	271.7	46.94	272.5	47.04	273.3	47.13	274.2	50

To find the width of the middle section, add together the widths of the end sections and divide by 2; the centre height is found in the same manner.

For convenience, the quantities in the tables should be still further divided by 2, so that it will only be necessary to divide by 3 instead of by 6, as above.

When *ef*, the base, or *r*, the ratio of the slope, changes, of course it will be necessary to use a new table. The specimen table given on pages 596 and 597 is part of the practical table for the base 18 ft. slopes 1 to 1.

The width of the section or distance between side stakes, is given in feet in the left hand column up and down the page, and the tenths from 0 to 9 across the top.

At the intersection of the feet and tenth columns, the centre height multiplier for a section, so many feet and tenths wide is found, and also a number to be added to the product.

When the number of tenths in the centre height is considered a whole number, three decimals should be pointed off in the product.

TO USE THE TABLES.

As each quantity in the tables is the product of a constant and an area, we can use them either for finding the true quantity by the prismoidal rule, or for the approximation by averaging end areas. In the latter case it will only be necessary to find the quantities for the end sections and add them together.

In practice, averaging areas gives a small average error in railroad work, although in the particular case of the pyramid it amounts to 50 per cent. of the whole volume, and in wedges about one-sixth or seventh. This method always produces too great a quantity, while on the other hand the system often employed of using the middle area alone gives too little, and in the case of the pyramid only three-fourths of the contents of the solid.

Since the tabular quantities are produced from the areas by a constant multiplier, we have the rule:

To find the area of any section, multiply the quantity found from the tables by 54.

EXAMPLE BY THE PRISMOIDAL RULE.

Let the first section be called Station O, and the second station 1; the centre cut of the first = 9.8 ft.; the distance from the centre to the left side stake (L. S.) = 20. 2ft., and to the right stake (R. S.) = 16.3 ft.

In the second section let the cut = 15.6 ft., L. S. = 23.9 ft., and R. S. = 26.5 ft.

Putting these data in the tabular form, leaving room between the sections to write their mean quantities or the corresponding data of the middle section, and supposing the base 18 ft. and the slopes 1 to 1, then from the specimen table we have the calculation as below.

Sta.	Cut.	L. S.	R. S.	Sum of Side Dists.	Quantities.		Total Quantities.
0	9.8	20.2	16.3	36.5	33.79 9.8 27032 30411 331.142	154.2 331.1 485.3	485.3
Middle Section.	12.7	....	....	43.4	40.19 12.7 28133 8038 4019 510.413	211.7 510 4 722.1 4 2888.4	2888.4
1	15.6	23.9	26.5	50.4	46 67 15.6 28002 23335 4667 728.052	270.0 728.1 998.1	998.1 3)4371.8 1457.3

As the tabular form here employed is the one in common use in the Field Book, the whole calculation of quantities is easily introduced into its proper

place in the records of the work. Referring to the example by adding together the total quantities for the end sections, we find the cubic yards by averaging end areas to be 1,483.4, which is 26.1 more than 1,457.3, or between $1\frac{1}{2}$ and 2 per cent. error, and by doubling the quantity for the middle section, we have 1,444.2 or 13.1 yards less than by the prismoidal rule.

ADVANTAGES OF USING THE TABLES.

In gaining the above result, we have referred to tables 3 times, made 3 multiplications by tabular quantities, and 1 by 4; there were also 4 additions and 1 division, making in all 12 processes.

Without the tables, we should have been compelled to multiply the extreme width by the centre cut; the sum of side heights by half the width of roadway; to add together the products and divide by 2, making 2 multiplications, 1 addition, and 1 division; or 4 processes for merely finding the area of each section, or 12 for the 3 sections; besides, it would have been necessary to note the side heights or employ the ratio of the slope in the calculation, making it longer.

To find the 4 side heights, to multiply the middle area by 4, to add, to multiply by 100, to divide by 6, and then by 27, makes 9 processes more than by the tables, or 8, when we unite the last 2 divisions, or divide by their product.

Since, generally, we will have the quantity for the first section from the preceding calculation, or, in other words, the area of each section will be used twice, in practice, the prismoidal quantity will be obtained by 9 processes, and an approximation by averaging areas, will require only 4.

There is less liability to error as the operations are fewer and simpler in this than in other methods, and any assistant can easily be taught to use it and the accuracy of his work readily tested.

THE TEMPERATURE OF THE SUN.

By CAPTAIN JOHN ERICSSON.

From "Nature."

The increase of the volume of atmospheric air, under constant pressure, being directly proportional to the increment of temperature, while the coefficient of expansion is 0.00203 deg. for 1 deg. of Fahrenheit, it will be seen that a temperature of 3,272,000 deg. Fahr. communicated to the terrestrial atmosphere would reduce its density to $\frac{1}{6643}$ of the existing density. Accordingly, if we assume that the height of our atmosphere is only 42 miles, the elevation of temperature mentioned would cause an expansion increasing its height to $6643 \times 42 = 279,006$ miles. This calculation, it should be observed, takes no cognizance of the diminution of the earth's attraction at great altitudes, which, if taken into account, would considerably increase the estimated height. Let us now suppose the atmosphere of the sun to be replaced by a medium similar to the terrestrial atmosphere raised to the temperature of 3,272,000 deg., and containing the same quantity of matter as the terrestrial atmosphere for corresponding area. Evidently the attraction of the sun's mass would under these conditions augment the density and weight of the supposed atmosphere nearly in the ratio of 27.9 : 1; hence its height would be reduced to $\frac{279,006}{27.9} = 10,000$ miles. But if the atmosphere thus increased in density by the sun's superior attraction consisted of a compound gas principally hydrogen, say 1.4 times heavier than pure hydrogen, the height would be $10 \times 10,000 = 100,000$ miles. The pressure exerted by this supposed atmosphere at the surface of the photosphere would obviously be $14.7 \times 27.9 = 410$ lbs. per sq. in., nearly. Unless, therefore, the depth greatly exceeds 100,000 miles, and unless it can be shown that the mean temperature is less than 3,272,000 deg. Fahr., the important conclusion must be accepted that the solar atmosphere contains so small a quantity of matter, that, notwithstanding the great depth, it will offer only an insignificant resistance to the passage of the solar rays. Now, the assumed mean temperature, 3,272,000 deg., so far from being too high, will be found to be considerably underrated. It will be recollected that the

temperature at the surface of the photosphere, determined by the ascertained intensity of solar radiation at the boundary of the earth's atmosphere, somewhat exceeds 4,035,000 deg. Consequently, as the diminution of intensity caused by the dispersion of the rays, will be inversely as the convex areas of the photosphere and the sphere formed by the boundary of the solar envelope, viz., 1.52 : 1, the temperature at the said boundary will be

$$\frac{4,035,600}{1.52}=2,654,000 \text{ deg.}$$

The true mean, therefore, will be 3,344,800 deg., instead of 3,272,000 deg. Fahr., a difference which leads irresistibly to the inference that, either the solar atmosphere is more than 100,000 miles in depth, or it contains less matter than the terrestrial atmosphere, for corresponding area. It will be demonstrated hereafter that the retardation of the rays projected from the border of the photosphere consequent on the increased depth of the solar atmosphere (supposed to be the main cause of the observed diminution of energy near the sun's limb), cannot appreciably diminish the intensity of the radiant heat. The ratio of diminution of the density of the gases composing the solar atmosphere at succeeding altitudes, is represented by Fig. 5, in which the length of the ordinates of the curve *a d b* shows the degree of tenuity at definite points above the photosphere. This curve has been constructed agreeably to the theory that the densities at different altitudes, or what amounts to the same, the weight of the masses incumbent at succeeding points, decreases in geometrical progression as the height above the base increases in arithmetical progression. The vertical line *a c* has been divided into 42 equal parts, in order to facilitate comparisons with the terrestrial atmosphere, the relative density of which, at corresponding heights, is obviously as correctly represented by this diagram as that of the solar atmosphere. It is true that, owing to the greater height of the latter compared with the attractive force of the sun's mass, the upper strata of the terrestrial atmosphere will be relatively more powerfully attracted than the upper strata of the vastly deeper solar atmosphere. The ordinates of the curve *a d b* will therefore not represent the density quite correctly in both cases. The discrepancy, however, resulting from the relatively inferior attraction of the sun's mass at the boundary of its atmosphere, will be very nearly neutralized by the increased density towards that boundary, consequent on the great reduction of temperature—fully 1,380,000 deg. Fahr.—caused by the dispersion of the solar rays before entering space. It may be well to add that, in representing the relative height and pressure of the terrestrial atmosphere, *a c* in our diagram indicates 42 miles, while *b c* indicates a pressure of 14.7 lbs. per sq. in.; and that in representing the solar atmosphere, *a c* indicates 100,000 miles, and *b c* 410 lbs. per sq. in. Bearing in mind the high temperature and small specific gravity, the extreme tenuity in the higher regions of the solar atmosphere will be comprehended by mere inspection of our diagram. Already midway towards the assumed boundary, the density of the solar atmosphere is so far reduced that it contains only $\frac{1}{152000}$ of the quantity of matter contained in an equal volume of atmosphere at the surface of the earth.

Let us now consider the diminution of intensity occasioned by the increased depth through which the heat rays pass which are projected from the receding surface of the photosphere. Fig. 6 represents the sun and its atmosphere extending $\frac{1}{4}$ of the semi-diameter of the photosphere, *m h*, *c g*, etc., etc., being the heat rays projected towards the earth. The depth of the solar atmosphere at a distance of $\frac{19}{20}$ of the radius from the centre of the luminary will be seen to be only 2.0012 greater than the vertical depth. Now, careful actinometer observations enable us to demonstrate that when the zenith distance is under 60 deg. the radiant energy of the sun's rays in passing through the terrestrial atmosphere is very nearly in the inverse ratio of the cube root of the depth penetrated (see the previously published table). The increase of depth resulting from atmospheric refraction, it may be well to observe, is too small at moderate zenith distances to call for correction ; nor does the atmospheric density vary sufficiently during bright sunshine to affect the radiant intensity appreciably. The table adverted to shows that an increase of the sun's zenith distance of 5 min. in 60 deg., occasions a diminution of temperature hardly amounting to 0.044 deg. Fahr. Adopting the same

rate of retardation for the solar atmosphere as that observed in the terrestrial atmosphere, it will be found that the loss of radiant energy of the solar rays at $\frac{1}{20}$ of the radius from the border of the photosphere will be only 1.26 greater than at its centre. According to the researches of Secchi and others, the loss is fully three

Fig. 1

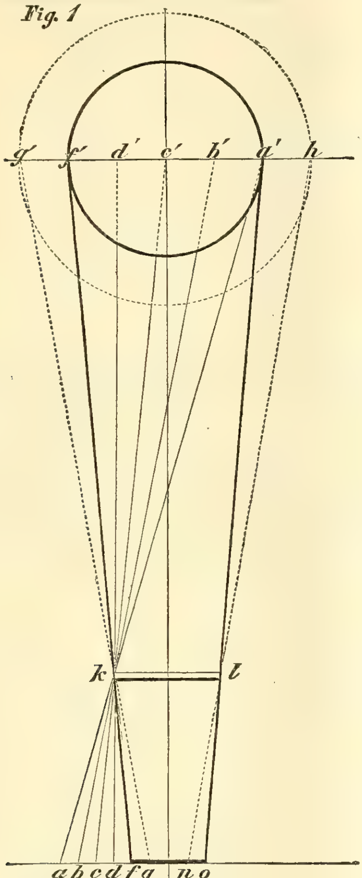


Fig. 2

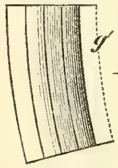


Fig. 3

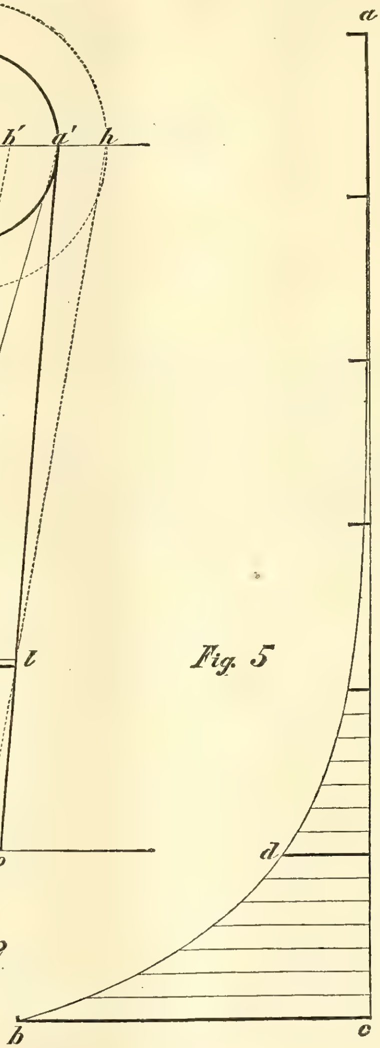
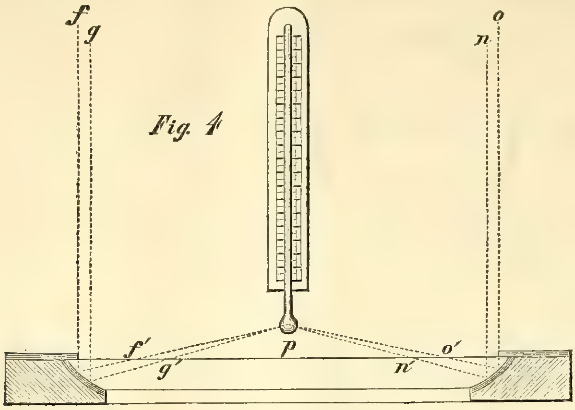


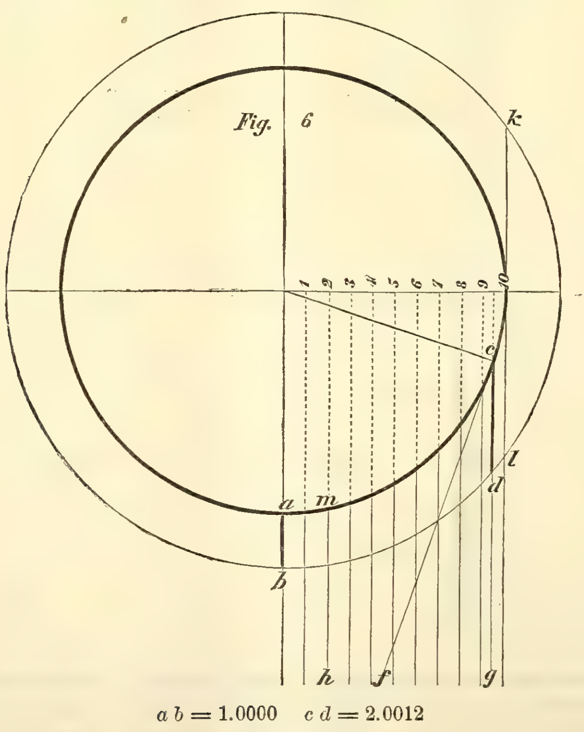
Fig. 5

times greater than that established by the rate of diminution which we have adopted. This circumstance, in connection with the extreme tenuity of the solar atmosphere, rendering any considerable loss improbable, points to the fact that some other agency than increased depth is the true cause of the diminution of the temperature under consideration. Accordingly, the writer some time ago instituted a series

of experiments with incandescent cast-iron spheres, for the purpose of ascertaining practically if the reduction of temperature could be accounted for solely on the ground that the obliquity of the rays diminishes their energy. Previous experiments had demonstrated that the accepted doctrine is quite incorrect, which teaches that heat rays emanating from the surface of incandescent radiators are



projected with equal energy in all directions. It was found during those experiments that the ratio of diminution of radiant heat transmitted to a stationary thermometer by an incandescent circular disc of cast iron, turning on appropriate journals, is directly proportional to the sines of the angles formed by the face of



$a\,b = 1.0000$ $c\,d = 2.0012$

the disc and lines drawn to the centre of the bulb of the stationary thermometer. It was clearly shown that those heat rays only which are projected at right angles

to the face of the incandescent radiator, transmit maximum energy. The important bearing of this fact with reference to temperature transmitted by the heat rays of the photosphere from points near the border, is self-evident. The small angle formed by the ray *c g*, Fig. 6, and the tangent *c f* of the surface of the photosphere at *c*, explains satisfactorily why the radiant heat at a distance of $\frac{1}{20}$ of the radius from the sun's border, is considerably less than at the centre. It will be perceived that the angle *f c d* diminishes very rapidly as the border of the photosphere is approached, and that when the extreme point is reached, the radiant heat transmitted would be infinitesimal if the irregularity of the surface of the photosphere did not present a series of inclined planes capable of projecting heat rays in a direct line with *k l*.

Laplace, in the famous demonstration by which he proves that "if the sun were stripped of its atmosphere, it would appear twelve times as luminous" ("Mecanique Celéste," tom iv., pp. 284—288), commits the grave mistake of assuming that all rays emanating from a radiant surface possess equal energy. This assumption leads him further to the erroneous conclusion that the rays projected from the retreating surface of the sun near the limb, act as rays from a lens, being crowded together in consequence of the obliquity of the radiant surface, thereby, he supposes, acquiring increased intensity; hence the monstrous assertion of the great mathematician, that, but for the interference of the solar atmosphere, the luminosity would be twelve times more intense.

The important question whether the solar atmosphere possesses any appreciable radiant power, and whether the high temperature of the attenuated matter of which it is composed, exercises any marked influence on the sun's radiant energy, may unquestionably be answered practically. An investigation, based on the expedient of concentrating the heat rays of the chromosphere by means of a parabolic reflector, has been conducted by the writer for some time. The method adopted is such that only the heat rays, if such there be, from the chromosphere and exterior solar envelope, are reflected; while the rays from the photosphere are effectually shut out. Fig. 1 shows the general arrangement; *f′ a′* represents the photosphere, and *g′ h* the boundary of the surrounding atmosphere; *k l* is a circular screen exactly 10 in. in diameter, placed 53.76 in. above the base line *a o*. This distance obviously varies considerably with the seasons. Assuming that the investigation takes place when the sun subtends an angle of 32 min. 1 sec., the screen *k l*, if placed at the distance mentioned, will throw a shadow, *f o*, exactly 9.5 in. diameter; hence objects in the plane *a o* placed within *f o*, will be effectually shut out from the rays projected by the photosphere, while they will be fully exposed to the rays, if any, emanating from the chromosphere and outer strata of the solar envelope.

It should be observed that, owing to diffraction in connection with the extreme feebleness of the sun's rays projected from the border, the shadow thrown by the screen *k l* extends considerably beyond the circular area defined by *f o*. Fig. 3 exhibits a *full size* segment of this shadow as it appears round *f o*, the section colored black in Fig. 2 being a photometric representation of the strength of the said shadow from *f* to *a*. Special attention is called to this photometric representation, as it shows that objects placed within the circular area defined by *f o* are absolutely screened from the rays of the photosphere. It is evident that a parabolic reflector of proper size placed immediately below *f o*, will concentrate the radiant heat, if any, transmitted by the rays *f′ f* and *g′ g*, and the intermediate rays. Fig. 4 represents a section of the parabolic reflector which has been employed during the investigation. It consists of a solid wrought-iron ring lined with silver on the inside, turned to exact form and highly polished. An annular plate 9.5 in. internal diameter, is secured to the top of the wrought-iron ring to prevent effectually any rays from the photosphere reaching the reflector. The prolongation of the rays *f′f* – *g′ g* and *h n* – *a′ o* are shown by dotted lines *f g*, and *n o*; also the reflected rays directed towards the bulb of the focal thermometer, marked respectively *f′*, *o′* and *g′*, *n′*. The investigation not being yet concluded, the following brief account is deemed sufficient at present. Turning the reflector towards the sun, without applying the screen *k l*, a narrow zone of dazzling white light is pro-

duced on the black bulb of the focal thermometer, the mercurial column commencing to rise the moment the rays strike the reflecting surface. With a perfectly clear sky, the column, during an experiment on August 29, 1871, reached 320 deg. Fahr. in 35 sec. The screen $k\ l$ being applied after cooling the thermometer, a zone of feeble grey light appeared on the black bulb nearly as wide as the one produced by the rays from the photosphere, but situated somewhat lower. The column of the focal thermometer, however, remained stationary, excepting the oscillation which always takes place when a thermometer is subjected to the influence of the currents of air unavoidable in a place exposed to a powerful sun. It is proper to remark that, owing to the stated oscillation, it cannot be positively asserted that there was no heating whatever produced by the reflection and concentration of the rays which formed the zone of grey light adverted to. But the recorded oscillations prove absolutely that the heating did not *exceed* 0.5 deg. Fahr.

Assuming that such a temperature was actually produced by the reflected concentrated heat emanating from the solar envelope, the following calculation will show that the energy thereby established is too insignificant to exercise any appreciable influence on the sun's radiant power. Theoretically, the temperature transmitted to the bulb of the focal thermometer by the rays f and o, Fig. 4, is inversely as the foreshortened illuminated area of the reflector to the zone of light produced on the bulb. Obviously these areas bear nearly the same relation to each other as the squares of f' or o' to the square of the radius of the bulb p. The length of f' being 4.77 in., while the radius of the bulb is 0.125 in., calculation shows that the temperature transmitted by the ray f would be increased 1,456 times if the reflector did not absorb any heat. Allowing that 0.72 of the heat is reflected, the augmentation of intensity by concentration will amount to $0.72 \times 1{,}456 = 1{,}048$ times the temperature transmitted by the rays f and o. The records of the oscillations of the mercurial column during the experiments show, as stated, that the temperature resulting from concentration cannot exceed 0.5 deg., hence the temperature transmitted by the rays emanating from the heated matter of the solar envelope will only amount to

$$\frac{1}{2 \times 1084} = 0.00047 \text{ deg. Fahr.}$$

The observations having been made when the sun's zenith distance was 32 deg. 15 min., a correction for loss occasioned by retardation amounting to 0.26 will, however, be necessary. This correction being made, it will be found that the heat actually transmitted by the rays from the solar envelope during the experiment of August 29, did not exceed 0.00059 deg. Fahr., a fact which completely disposes of Secchi's remarkable assumption that the high temperature of the photosphere is owing to the "radiation received from all the transparent strata of the solar envelope" (see his letter to "Nature," published June 1, 1871). But we are not discussing the cause; the degree of temperature at the surface of the photosphere is the problem to be solved.

It was stated in the previous article that the radiant power of incandescent metals, and metals coated with lamp-black and maintained at boiling heat, is directly proportional to the temperature of the radiator. A series of experiments with flames just concluded, proves positively that under similar conditions a given area of flame of uniform intensity transmits the same temperature as incandescent cast iron. Secchi's assertion, therefore, that the photosphere, if composed of incandescent gases, "may have a very high temperature and yet radiate but very little," is wholly untenable. The diminution of intensity attending the passage of the heat rays from the photosphere through the surrounding atmosphere, is the only point which can materially affect the question of temperature. We have shown that on a given area, the quantity of matter contained in the solar atmosphere cannot greatly exceed that of the terrestrial atmosphere; hence the retardation cannot be great. True, the depth of the solar envelope is vast compared with that of the earth's atmosphere, but distance *per se* does not affect the propagation of radiant heat. Admitting, however, the retardation to be as the cube root of the depth—the ratio observed in the terrestrial atmosphere—it will be found that the loss of energy produced by retardation of the heat rays is not important. The solar atmosphere being

$$\frac{100{,}000}{42} = 2381$$

times deeper than the earth's atmosphere, the retardation caused by the former will be 13.3 times greater than that of the terrestrial atmosphere, which, as we know, diminishes the radiant intensity 17.64 deg. on the ecliptic. Accordingly we are justified in asserting that 13.3 $\times$ 17.64 deg.= 234.6 deg. Fahr. will be the greatest possible diminution of temperature caused by the retarding influence of the matter composing the solar envelope. The admission in the previous article, that the retardation under consideration might be 0.01, was based on the extreme assumption that the obstruction is directly proportional to the depth of the sun's atmosphere. At first sight, the loss of 234.6 deg. appears to be a trifling reduction of energy; yet if we consider the mechanical equivalent which it represents, we cannot doubt its adequacy to supply the motive force expended in producing the observed movement of the attenuated matter within the solar atmosphere. Dividing the temperature of the photosphere, 4,035,000 deg., by 234.6, it will be found that the computed, apparently insignificant, retardation exceeds $\frac{1}{17,000}$ of the entire dynamic energy developed by the sun—an amount fully 15,500 times greater than the solar energy transmitted to all the planets of our system! Making due allowance for the extreme attenuation, and the small quantity of matter to be moved, the most exaggerated computation of the probable expenditure of mechanical energy called for in keeping up the currents of the solar atmosphere, fails to establish an amount at all equal to that capable of being generated by utilizing 234 deg. of the radiant heat emanating from the photosphere.

In view of the foregoing statements, and the demonstrations contained in the previous article on solar heat, we cannot consistently refuse to accept the conclusion, that the temperature at the surface of the photosphere is very nearly 4,036,000 deg. Fahr.

CRITICAL EXAMINATION OF THE IDEAS OF INERTIA AND GRAVITATION.

By JAMES D. WHELPLEY.

7.—THE LAWS OF FALLING BODIES.

In section No. 1* I have given a series expressing the increase and diminution of motivity in a planet moving in an elliptical orbit, and whose distance from the sun is continually changing. The velocity of such a planet was found by Kepler to vary inversely as the distance from the sun, and I have assumed that the force which unites the planet and the sun varies in the same ratio; the multiplication of the two series giving a third which expresses the ratios of motivity generated in the planet by the solar influence at different distances. Newton made the intensity of gravitation to vary as the square of the distance inversely; giving a series precisely similar in value with that which is obtained in sec. 1, by multiplying the inverse velocities into the inverse intensities of the actuating force. But there are still other series expressing the same mathematical conditions. We may assume that the intensity of gravitation in a planet approaching the sun, varies as the square of the velocity of the planet; which will give the same series, but will not express any physical truth or law; velocity being in no sense a *cause*, but always a result of force. Another series, which not only contains the mathematical but the physical truth, is obtained by squaring the series of numbers that express the intensity of gravitation; *assuming*, always, that gravity varies simply as the distance inverse. The series given in sec. 1, in which the velocity is multiplied into the force, is defective, because it also implies that velocity is a cause, or multiplier.

It will be presently demonstrated, by analysis of the phenomena of falling bodies that the effect of the solar influence in producing motor force, or momentum, is as the square of its intensity; and the series of these squares corresponds with the Newtonian formula of the distance square inverse.

The modern idea of motor force did not exist in the Newtonian system.

A careful analysis of the laws of falling

* See page 496 of this Journal for November, 1871.

bodies will enable a much clearer understanding of all of these points.

A body is said to be "falling," when it is approaching the earth from a short distance under the influence of gravity. Newton first showed the necessity for regarding the action of gravity as mutual between the falling body and the earth; each moving the other with equal force, but with velocities inversely as their masses.*

It is hardly necessary to say that a falling body near the earth moves in an orbit, holding in fact a true planetary relation with the earth.

To simplify the problem, we may regard the trajectory of a falling mass as a straight line passing through the centre of the earth and of the body itself.

Near the level of the sea a body falls at the rate of 16 ft. and a fraction in 1 sec.; a rate too rapid for accurate measurement of the spaces passed over; but in Atwood's machine, a weight is retarded by a counter weight, so that its velocity may be reduced to 1 ft., or less, for the first second of time, the law of acceleration acting through successive seconds as if the weight were free.

Let the weight, then, be falling 1 ft. in the first second of time. This is not a slow movement of falling, since it is known that if the earth were to begin now to fall into the sun, it would move during the first second only a little more than one-tenth of an inch.

In falling 12 in., beginning from rest, or no velocity, the weight acquires a velocity of 2 ft. per sec. It has had then, an *average* velocity of 1 ft. per sec. During the next second, the weight having acquired a velocity of 2 ft. to begin with, is accelerated as much as in the first. At the end of the second second it has therefore acquired a velocity of 4 ft. During the third, beginning with a velocity of 4, it acquires by equal acceleration a speed of 6 ft. per sec. The *average* velocities of the first, second, and third seconds of falling, are 1, 3, and 5 ft. From these averages, John Bourne, in his Treatise on the Steam Engine has deduced the true or natural law of momentum, as follows:

The gravitation of the weight for short distances is assumed to be a constant force, which he calls a "pressure,"† represented by p. By the modern method of calculating motor forces, under the name of foot-pounds, or horse powers, the pressure, or actuating force, is multiplied by the velocity; and this, again, by the duration of the action.

"The power exerted during the first second was as the pressure$\times$velocity$\times$the time$=p\times1\times1$; in the 2d sec. $p\times3\times1$; and in the 3d, $p\times5\times1$; hence the total power exerted, was $p\times(1+3+5)=p\times9$."

From this we see that the power required to bring a body from a state of rest to a velocity of 6 ft. per sec. (end of 3d sec.) "is represented by 9, while the power required to bring the same body from rest to 2 ft. per sec., or *a third* of that velocity is only *one-ninth*." Hence, "to ascertain the power resident in bodies moving at different velocities, we must multiply the pressure by the square of the velocity." Pressure means simply actuating force.

If the weight of the Atwood machine is adjusted to fall 1 ft. in the first second, it will fall 9 ft. in 3 secs. by experiment. Its average velocity, in falling 9 ft., is then 3 ft. per sec. The actuating force, or unit of constant gravitation, multiplied into the velocity multiplied into the time$=p\times v\times t$ $=p\times3\times3=p$ 9, represents the motor force exerted during the 3 seconds;—and we know that this force is not wasted by friction, or expended in "work," but is accumulated in the momentum of the weight. We have here a perfectly simple method of proving that *the dynamic value of a mass moving under a constant force of gravity varies as the square of its velocity.*

Although engineers have long been acquainted with the fact mentioned by Nicholson, that the effect of a blow given by the ram of a pile-driver, is nearly as the distance fallen, or as the square of the average velocity, they have continued to repeat the false and useless formula of the Newtonian physics, that the "quantity of motion or momentum of a moving body is found by multiplying the mass into the velocity."

Indeed, the idea of motor force, as it is understood and employed by the moderns, is not dogmatic or hypothetical, but derived from observation. It belongs exclusively to the present century.

Motion and rest enter jointly into every form of motivity, under the general idea

* The idea of mutual gravitation originated with Kepler. See Maclaurin.

† This expression originated with Newton.

of equipoise ; *a disturbance of the equipoise of forces being the exclusive cause of motion, as their equilibrium is of rest.*

The modern idea of motor force (foot-pounds, horse-powers, etc.) includes the idea of resistance, rest or stability, and I have shown by former reasonings that the first effect of all masses upon each other is to impart stability, the element of rest and resistance—the principle of inertia.

The points to be observed in the phenomena of falling bodies are, then, as follows :

1. That the square of the time of falling represents the space fallen through.
2. That the square of the *average* velocity expresses the space fallen through.
3. That one and the same number expresses the space fallen through, and the momentum acquired at the end of the fall.
4. That the average velocity and the time of falling are expressed by the same number.
5. *That either the time of falling squared, or the average velocity squared, or the product of the two, represents the momentum acquired by the fall.*
6. That, with a constant actuating force, the increments of velocity are constant, and the same for every equal fraction of an unit of time.

It remains to consider the effect of an increase or diminution of the actuating force.

If a falling body be actuated from the first by three units of force instead of one unit, it must start with three units of velocity instead of one unit. Under these conditions the weight of the Atwood machine will fall 1 ft. in the first third of a second, 3 ft. in the second, and 5 in the third=9 ft. in 1 sec.

But this also expresses the momentum at the end of the first second; and we have reached the very important and novel conclusion, that, *other things being equal, the distance fallen in a given time, and the momentum at the end of the fall, will be as the square of the actuating force.*

Thus, then, it again appears, as we have already stated (secs. 1 and 7), *that the actuating force of gravitation increases in the simple inverse ratio of the distance ;* since a planet falling towards the sun through an infinitesimally small space, will fall with a momentum which is a square of the actuating force, that is to say, the square of the distance inverse of the planet from the sun.

8.—PLANETARY VELOCITIES.

The orbitual velocity of a planet varies, as it approaches and recedes from the sun, as the distance inversely, in a simple ratio (Kepler). The increase of velocity during its approach to perihelion, in the first half of its orbit, is due to the fact of its drawing near to the sun, under the law of acceleration ; while the actuating force, or cause of velocity, varies in the same ratio with the velocity, and not as the distance square inverse. The orbitual velocity is augmented, under the laws of falling bodies. The momentum of the planet in its orbit is thus increased during its approach ; and *the measure of its increase is found by squaring the intensity of the actuating force.*

When, on the contrary, two planets, for instance the Earth and Jupiter, are separately observed, it is found that the velocities of the two compared together, are in the inverse ratio of the *square roots* of their distances from the sun. Let two planets be distant from the sun, the first four, the second sixteen units of distance, the velocities of the two in their orbits would be as 4 to 2.

"The power that acts on a planet that is nearer the sun is manifestly greater than that which acts on a planet more remote; both because it moves with more velocity, and because it moves in a lesser orbit, which has more curvature, and separates farther from its tangent in arcs of equal length."*

Let two circular orbits of two planets be concentric, the sun being the centre, and the farther planet 4 times as distant as the nearer. The velocities of the two in orbit are known to be as 2 is to 1 (Kepler). Let both move in their orbit through small arcs for a minute of time, the nearer will have moved as far again in the minute, and will have fallen on the curve of the lesser orbit, away from the straight line or tangent, 16 times as far as the other, as may be seen by inspecting a diagram of the movement. But the distances fallen through in equal times by falling bodies, such as the planets falling toward the sun, measure the force which

* Maclaurin, p. 267. The explanation is condensed from his.

causes the fall. The force exerted by the sun upon the nearer planet is consequently 16 times greater than upon the other in equal times; the force exerted by the sun being thus found to be always in the ratio of the inverse square of the distance. Upon the above argument Newton founded his entire system, always assuming that orbitual motion is determined by the "continual falling" of the sun and planets toward one another (in the mean orbit), whereas they do not fall at all, but are mutually at rest, maintaining a constant mean distance. But even if this hypothetical "falling" of bodies that do not fall were admissible, the inference drawn by Newton is incorrect; for I have shown in the analysis of the laws of falling bodies (sec. 7), that the distances fallen in equal times by different bodies will vary *as the squares of the intensities of the actuating forces*. By which it appears that the actuating forces of gravity vary inversely as distance, and not inversely as distance square.

Some very useful deductions may be made from the observation of planetary velocities. We have seen, that when the planets are moving in elliptical orbits, they are vibrating to and from the sun—under the law of "falling" bodies—one vibration being completed during each solar period.

Because of this change of distance, and consequent change of dynamic relation, we find the actuating or radial force evolving motor forces, in the ratio of the square of its own intensity, during such time as the planet is approaching the sun; and the reverse during its recession.

If, then, a system of planets are revolving in relation with the sun, in circular orbits, *the sun and each one of the system of planets are at rest—in regard to each other*; and because they *are* at rest, the gravitating force evolved between them is, in the radial direction, only inversely as their solar distances. But if the length of the *radius vector* shall vary in the smallest degree—changing the distance between the planet and the sun—the *radial force evolved in the mass* at different distances from the sun, will not be in this simple ratio, but "*as the square of the intensity of the actuating force*," that is to say, *inversely as the squares of the distances.*

It seems hardly necessary to urge so simple an idea, as that the planet and the sun, when at rest in regard to each other, evolve motor forces only in the direction of the orbitual motion.

9.—NATURAL CAUSE OF ORBITUAL MOTION.

To reverse the motion of a moving mass and send it back upon its course in the opposite direction, a force of opposition is required (as in the case of the rebound of an elastic ball), just equal to the momentum of the mass. The direction of the earth's motion in the heavens is exactly reversed in passing from aphelion to perihelion; and a second reversal is effected in the next semi-period; so that *we find the sun's work, in foot-pounds, done in guiding the earth in its orbit from the first of the year to the end of it, is just equal to twice the mean momentum of the earth.*

The original or proper momentum of the terrestrial mass, such as it would be without the guiding action of the sun, is fully taken up in the first half of the year, and again in the second half; so that, in result, *the terrestrial momentum is always a sum of solar effects.*

Because there is no variation of distance between the sun and a planet moving in a circular orbit (mean orbit), there can be no development of motor force in the direction of the *radius vector*. *But it is certain, that a force is developed*, and it appears in the form we have described. *A guiding or directive force* is mutually evolved in the earth and in the sun, by their fundamental relation. We have seen that this force operates as a constant pressure, and its result in foot-pounds during one annual period is equal to twice the product of the earth's mass into the square of its velocity.

It has been calculated by astronomers that the effect of solar gravitation upon the mass of the earth amounts to $\frac{1}{1600}$ of the proper or self-gravity of the mass upon itself. A mass weighing 1,600 lbs. at the earth's surface is affected by the sun with a force of only 1 lb. But this force, generated by solar relation, and wholly independent of the *proper* inertia of the earth, due to its action upon itself, is "*floated*" on the earth's orbit, and takes the form of inertia.

Hitherto all philosophers have agreed to regard the orbitual curve as produced either by a constant "drag" or a constant "push" of the gravitating force, against the tangent impetus; but it will be much better to look for a probable cause of

orbitual motion, derived from known conditions. We know, for example, that the action of solar gravity is greater on the bright than on the dark side of the earth, because the bright side is 7,912 miles nearer the sun. If, then, the actuating force is inversely as the distance, the difference between the two sides will be as 91,007,912 is to 91,000,000. But the velocities of the two sides of the earth differ directly, and not inversely, as the distance; *the remote or dark side having the longer journey to perform in an equal time.*

We have seen that the actuating force does not evolve motivity in *radius;* the distance between the planet and sun being supposed constant. In the direction of the orbit, on the contrary, there is motion; and consequently, *the motor values of the actuating force at the less and greater distance, determined by the diameter of the planet, will be inversely as the squares of the intensities of that force, at these points.* These quantities are so modified by the differing and inverse velocities of the nearer and farther parts, that the momenta of each particle of the planetary mass will be found equal, as long as the orbit is circular. Let P^2 and p^2 represent the greater and less, or nearer and farther, evolutions of force *in the mass.* To find the motivity, these must be multiplied by the squares of the two velocities, V and v, *which are inversely as the intensities of the actuating forces in any given particle of the mass.*

Let V=greater and v=lesser velocity,

$V \times p = v \times P$, or $V^2 \times p^2 = v^2 \times P^2$.

From which it appears, that in all cases of circular orbits the orbitual momentum is the same and equal for every equal particle of the planet; *the variations of velocities due to the curve, correcting the varying intensity of the actuating force, due to the differences of distance.*

If a planet were moving in a straight line, all the particles would move with equal velocity and momentum; and it would be by reason of this equality that the course of the planet was straight. The perturbing influence of the sun and of all other celestial bodies, produces movements of a highly complicated nature; but always governed by the same equation of momenta. The principle of orbitual motion is, that *in all masses or dynamical systems moving freely in space, the momenta about the axis of movement are equal..* The nature of the curve is determined by the equation of momenta about the axis, compounded of intensities and velocities. The solar and other celestial influences serve only to evolve the forces *in the mass;* the orbit being the sign of equality between them.

These views do not allow us to imagine that the sun or moon, or any other external force, "drags," "pulls," "pushes" or "presses" the planet away from its "natural" orbit—supposed to be the straight line—into a curve of motion, which is a compromise between contending influences. A "straight" line orbit would be determined by the same laws that determined any curve of motion; nor is one more "natural" than another.

If a planet is moving in a straight line or in a circle, we have seen that the momenta are mathematically equalized about the axis of motion *in the mass;* that axis being in the one case a right line and in the other an arc of a circle; the smallest possible deviation from these, would cause in either case a shift of the axis of equality, and this constitutes a "perturbation" and a change of orbit. But the same law applies to curves of the highest complexity, the direction of the motion being in every case determined so as to effect a balance of the forces.

IRON AND STEEL.

From "The Builder."

The hitherto undiscovered causes of results, apparently so inexplicable and contrary in their effects, to what would otherwise be rules by induction to guide us in our anticipation of producing various kinds of iron and steel, which should possess properties in each case varying in degree in proportion to the quantity of the agent inducted, which should in any proportion give, or appear to give, existence to those properties, must necessarily cause reflection in the minds of many readers, and should, therefore, it may be hoped, be productive of at least a few in-

crements of further discovery and elucidation on the subject.

The consideration of these anomalies presents the following hypotheses, and their resulting conclusions, confirmed, partly at least, by known facts and experiments previously made: Concerning the introduction of carbon in differing quantities producing apparently opposite effects, we may be led to speculate not only on the result effected *in toto*, but on the result produced on the atoms of which it is composed, considering these to be between minute cells, separated from each other by what are usually called the fibres of the iron or steel.

The cells, however minute they may be, will have a defined form, which probably will alter, at the least a little, by any change that may by any means be produced; the variations in the temperature of the weather must produce an increased or diminished size, according to its degrees (and although, perhaps, somewhat foreign to the nature of the investigations we intend at present to pursue, we may pause an instant to consider whether, when a bar of iron increases in size with heat, it increases in exactly the ratio in weight), and the fibres would necessarily alter in consequence, and the question occurs, how would they alter? Would they become thinner in proportion to the cells they inclose, or would they continue to have the same proportion to these cells? And, again, what do these cells contain?

As iron contains carbon and oxygen increasing in proportion as we take samples, beginning with the white iron and going through the various kinds, as mottled iron, bright iron, and the gradations of foundry iron, it would seem probable that the cells in these latter kinds are occupied by oxygen and carbon, and that one or both of these conduce to, or, perhaps, entirely cause brittleness, and that the cells in the foundry iron are much larger than those in the malleable iron. This theory will appear likely from the consideration that foundry iron is lighter than forge iron, and the equivalent of (C) =6, (O)=8, and iron (Fe)=28.04, and twice the size of (C); then the difference in weight of (C) and (O) combined in the larger cells of the foundry iron, and of the weight of the iron itself, corroborates the hypothesis that those cells exist, though, in common with atomic bodies, they are quite invisible by the most powerful microscopic observation.

But it may be urged that these could not exist in forge iron, else how could a bar be drawn out to (say) $\frac{1}{1000}$ part of its previous size? Would those cells then be 1,000 times as long as they were before? If so, then the fibres would be only $\frac{1}{1000}$ part in area, and how could they hold together, either to each other or lengthwise?

In answer to this, let us consider that perhaps the most important and remarkable property of forge iron is that it is almost, or quite, impossible to fuse it (and most probably because its atoms have a powerful and adhesive affinity for one another, which is much interrupted by the carbon in the foundry iron), and therefore it is possible that it may be extended 1,000 times, and not part; but if they would not, we may consider the atoms of this malleable and pliable metal to be like marbles filling a box of, say, 3 ft. by 2 ft. by 2 ft., and their surfaces (although only touching at places) to have so powerful an adhesion as only to be moved, but not separated without being torn asunder or cut, and the interstices between them to be nearly filled by additional portions of iron, which should, being pliable (as we must consider our marbles to be) accommodate themselves to the changing form of the respective atoms to which they must be considered to belong; and let us consider that these interstices contain the cells; then it must be evident that if heat and pressure combined would cause these to slip one upon another, the pressure rendering them perhaps a little elongated, or acorn-shaped, and the cells likewise, and therefore reduced in cubic space within; and if the box, in performing this, were previously to have had its ends removed, then the continuance of the pressure would reduce the contents to 12 ft. by 1 ft. by 1 ft.=its previous cubic contents. This theory of atoms and cells and adhesive properties in malleable iron must be admitted to be possible, because chemists admit atoms to exist, and that they cannot tell their form; and cubes, squares, triangular, hexagonal, or lozenge-shaped prisms can be the only atoms that could leave no interstices, and these are improbable, because they would not easily, if at all, move one upon another in laminating;

therefore, as atoms of any other form must leave cells, then they are at least probable, and also because those atoms are held to be impenetrable; and if there were no cells, then there could be no possibility of their containing carbon. Admitting this, we are bound to consider that when sufficiently heated, the atoms of iron admit the passage between them of the atoms of carbon, and the increase in the size of iron when heated will, perhaps, support this idea; but in this we must not suppose that all the atoms part entirely for the time being; they may act alternately, which might account for the sparkling appearance of iron when at a white heat (the iron in which they would entirely part would, perhaps, be the moulten foundry iron). The foregoing hypothesis, if adopted as probable, leads to the supposition that carbon intervenes to some extent between the places of contact and adhesion, besides existing in the cells of iron, and considerably more so in foundry iron than in forge iron; and that hammering the latter, in increasing its specific gravity, forces its atoms closer together, and the carbon more fully into the cells, and more away from between the places of contact and adhesion of the atoms; and in this case the cells cannot previously have been completely occupied with carbon, and we may infer that they will not be fully so after our hammering; and it will be as evident, as universally known, that the hammering improves the tenacity and strength of the iron, because it brings its atoms closer together; and not only will they have a greater support from each other, but a greater number of them must present resistance to any given area of resisting surface.

It may also be the case, that the cells being nearly, if not quite, enclosed by the atoms, allow of little or no possibility of escape for the carbon and oxygen; and that when a considerable tensile strain is exerted on the iron, that the cells, becoming elongated, and therefore less in volume, exert an elastic force to allow the partial escape of one or other, or both, of the gases confined; and that if the gas or gases were not to find a sufficiently short and ready means of partial escape, that its elastic power (if caused by a sufficient strain) would rend asunder the atoms.

In applying a tensile strain to a bar of iron, the difficulty of escape for the gases must be greater the larger the area of the bar, and for the same reason a round or circular form of section would seem to be the least calculated to facilitate such escape, for if the same area were disposed in a slender, star-like form, the means of escape from the centre of section would be shorter and easier. This hypothesis will explain the fact, that a bar of iron which would bear a strain, when 1 in. sq., of 26 tons, would, when drawn out in the form of wire $\frac{1}{32}$ in. in diameter, bear a strain of 40 tons per sq. in.

In endeavoring to discover a hypothesis which may help to elucidate the cause of the effect produced by carbon in the manufacture of steel, we shall observe that of the four kinds of iron which could in any wise be considered as fit to be converted into steel, viz., grey iron, bright iron, mottled iron, and white iron, that only the bright iron and mottled iron will be really worth using, because the grey iron will be light and fibrous, and would take too much carbon; whilst the white iron (which is the closest grained, or not fibrous), although it is the best and most suitable for forge iron, is, nevertheless, not open or fibrous enough to admit—even with the expansion caused by the heat of the furnace—the induction of the carbon necessary that it should receive in order that it should become good steel.

The fact, however, that steel is heavier than forge iron can leave us, perhaps, no more probable inference than that its cells are fuller of carbon than those of the forge iron, and that its bulk is not greatly, if at all, altered; and that a piece of it may perhaps contain exactly the same quantity of carbon that a given piece of foundry iron contains, but that the piece of foundry iron will in consequence be greater in bulk and inversely lighter in weight than the piece of steel; this being an essential difference between cast iron and steel, the superior strength of steel might lead us to consider that the carbon, when admitted in exactly the right proportion, acts upon and causes the atoms to act upon each other with a vastly increased affinity or attraction, and this because the atoms are near or close to each other.

Tempered steel is lighter than soft steel, and it may therefore be considered that some of its carbon must, by caloric effect, have been eliminated; it is also more brittle and harder; and there is, conse-

quently, a striking analogy in this respect between the comparison of soft steel, with tempered steel, and that of forge iron with foundry iron.

If the heat causing the elimination were not suddenly absorbed by its immersion in pure or acidulated water, brine, mercury, oil, or tallow (for a second tempering after the first in water), or metallic compositions, or by being swung rapidly to cool in the air, then the consequent continuance of such eliminations would cause the steel to lose so much carbon that it would then not be much harder than forge iron.

The tempered steel, being lighter by the supposed extraction of a portion of its carbon, suggests the possibility that its vacated space will be occupied by some other element; if so, a different tempering medium may induct a different element, or the same one in a greater or less degree; from this it will appear probable that such element will be lighter than the carbon, and possibly the carbon remaining in the steel rapidly absorbs one of the lighter gases from the medium it is immersed in; hydrogen, from its lightness and large proportion in oxide of hydrogen would suggest that to be the gas.

This element, whatever it may be, will, while existing in steel, perhaps be of a more non-conducting nature than the carbon it has displaced; and as the latter is a powerful conductor of electricity, it would, when insulated in the steel, reduce in the atoms of steel the opposite kind of electricity (one positive and the other negative electricity), and the partial presence or absence of this electrical induction will perhaps sufficiently account for the superior strength of soft steel, and the greater brittleness of the tempered steel. This hypothesis would seem to be confirmed by the known fact, that magnetic ores and hydrated oxides are unsuitable to be manufactured into steel; this would be because they would be calculated to repel the induction of the carbon; being already charged with electricity, the one would repel the same kind of electricity in another element, viz., the carbon, and the hydrated oxide would repel either kind in another element if it should contain the same.

In order that steel should resist impact to the best advantage, it should the most nearly approach the hardest of forge iron, and should therefore contain the least possible quantity of carbon.

That steel shells should prove much more tenacious than iron when striking armor-plate could not perhaps at present be investigated with a greater chance of approaching the truth, than by supposing these to be of the most tenacious untempered steel, and which would probably have an excess of resisting power to compression, an approach to the malleability of white iron but retaining much of that elastic quality which renders steel so invaluable for springs, and so causes the shell to receive the shock somewhat in the manner that powerful springs receive the concussions of a heavy load in a carriage or cart, the heat caused by the concussion against the armor-plate liberating the carbon, and making the steel still less brittle.

The apparent anomaly of a 68-lb. shot shattering an armor-plate tempered in oil, would perhaps suggest the contemplation of the effect of concussion on a spherical body

If a projectile resists as much as it is resisted, then on striking an (to it) impenetrable object at rest, its own momentum only will react on itself, and its form, if spherical, will possibly cause the resistance to distribute itself through the shot in divergent directions, somewhat in the same manner that the weight of a large arch (under erection) is distributed by the struts in divers directions, and the fact of there being nothing but air behind the ball, would allow it a mobility and power of reaction which could not belong to it if it were resting on an anvil, and were to receive a blow (of exactly the same number of pounds' weight with the concussion) from a steam-hammer above it; but here the force would also be distributed as before, and possibly to a considerable extent counteract upon itself in a partly similar manner to the counteraction of forces manifested in striking the edge of a plank with an Indian club, when, if one particular part of its length touch (the edge of the plank), and that at about one-third the length from its large end, then there will be no vibration or shock to the hand; but if any other place in its length should touch the plank there will, and the same principle is also exemplified in a sabre, when bars of lead stood on end may, by a very strong and skilful

swordsman, have lengths cut off them by causing the right part of the sabre to touch the lead.

The armor-plate becoming shattered by the shot would perhaps be explained by the fact of its being steel at all, and still more so by its being tempered in oil, which is calculated to give the greatest hardness (for this reason oil is used for tempering mint stamps), and the quality that invariably accompanies that—viz., brittleness, and the backing on which it was mounted would also affect it; and in this the particular property of the plate as to brittleness or tenacity would make all the difference in the effect of the shot in the event of the plate not being solidly mounted—*i.e.*, if its backing does not touch it in all places alike. Suppose it to be hollow, and the shot to strike it in the centre and opposite such hollow, and suppose the metal to be tough and not brittle; then the only way in which the shot could effectively operate on it would be by driving a hole right through it, and its being hollow would immensely reduce the effect of the concussion; while on the other hand, if this tough but not brittle plate were fixed on a backing the least convex, then the shot could operate on its centre with its full force. And, on the contrary, if the plate were brittle and not tough, then experiment would probably prove that it would more readily break when slightly hollow at its backing.

And by a similar tendency in brittle steel, and to a lesser extent in soft steel, to fracture with concussion, we may perhaps see the reason why steel vent-pieces were more liable to fracture than those made out of tough iron, and they would probably be less likely to fracture than iron, if instead of being screwed into the gun (as I believe they were), they were to be very accurately turned to fit a corresponding hole to receive them, and (as the gun and the steel vent-piece would probably expand in different degrees under the changes of temperature) it would be well to give a slight draught downwards of (say) one in fifty, so that it could always be made to fit accurately, and thus prevent the vibration the screw vent-pieces would have.

To keep it down in its place the vent-piece should be made with a strong head or flange at top, longer than it is wide, and (to use artillerymen's phraseology) in the front and rear of this head should be a projection on the gun as high as the top of the cap, and these projections should continue over the top of the cap (as far as the latter extends beyond the circular part of the vent-piece), and to have strong screws to keep the cap and its vent-piece down.

To put the vent-piece in, it will only be necessary to turn it round a half circle, that its cap shall clear the screw projection as it goes down.

The vent would be continued through the cap, and which would cause no obstruction to the lanyard in firing the friction tube; but the tangent scale and foresight would in muzzle-loaders have to be placed a little higher.

THE NEW MONITOR TURRET SHIPS FOR COAST DEFENCE.

From "The Mechanics' Magazine."

It will be readily admitted that, while our supremacy on the seas must be maintained by an efficient fleet, of sea-going cruisers, comprising armor-clads, swift corvettes, and gunboats, fully capable of successfully encountering the combined navies of any two foreign powers, it is highly desirable we should possess in addition to these another class of vessels, forming what has been aptly termed a second line of defence, in case disaster should overtake our first line, or that strategy should for the time render it of no avail.

A beginning has been made to supply this desideratum by the four iron-clads ordered to be built by contract shortly after the commencement of the late continental war; they may be expected to be added to our navy in the early part of the coming year. They are of the type known as monitor turret-ships, and, although designed mainly for harbor defence, are yet capable of making considerable voyages under favorable circumstances, of which we have had experience in the voyages of the Cerberus to Australia, and of the Abyssinia and Magdala to India, these

monitors being almost precisely similar to those now building.

As these vessels have but 3 ft. 6 in. freeboard, it will be inferred that they can possess but little stability; such is the case, still they may perhaps have a sufficient amount, as they are not intended to carry sails, but we believe some doubt still exists on this point, and that a lightly-built structure will be made flush with the sides up to the height of the breastwork for a length of about 120 feet, which would make the freeboard upwards of 10 feet for that extent (as in the case of the Devastation, in accordance with the recommendation of the Committee on Naval Design). This will have the effect of considerably adding to the safety of the vessel, by increasing the angles of maximum and vanishing stability. Also to guard against excessive rolling, each of these monitors will eventually be provided with no less than three bilge-keels on each side, and it will be seen that these arrangements are highly desirable, by bearing in mind that the angle of vanishing stability for this class is only 39 deg., which is considerably less than that of the ill-fated Captain. As a set off to this fact, we must remember that the Captain was fully masted and rigged as a seagoing ship, while these monitors will carry no sails and only one mast in the centre, merely for the purpose of getting the boats in and out of place.

This sort of vessel will, on ordinary occasions, be hovering about our coasts, and as they must depend solely upon their steaming powers, it is highly requisite they should steer well. Experience having shown that twin screws are conducive to this result, each vessel will be driven by twin screws with engines of 250 nominal horse power, but the indicated power is required to be $6\frac{1}{2}$ times the nominal, propelling the monitor at an estimated speed of 10 knots per hour.

We consider the quantity of coals carried to be an important element in this type of war vessel, and therefore regret that the weight upon ordinary occasions is to be only 120 tons, as by increasing the breadth 1 ft. and the length 5 ft., which would not be a material increase in their moderate dimensions, 100 tons extra of coals might be carried, supposing the remaining part of the increased displacement to be taken up by the additional weight of engines, etc., for driving the ship at the same speed. We are aware that arrangements are made for coal space, so that 300 tons might be carried on an emergency, but this would necessitate sacrificing no inconsiderable portion of the already small amount of freeboard, which would be decidedly objectionable, especially if required to meet an enemy in unfavorable weather.

The dimensions of the monitors are, 225 ft. between the perpendiculars, 45 ft. extreme breadth, 16 ft. 2 in. depth of hold, 15 ft. 6 in. draught of water, tonnage B.O.M. 2,107, and total displacement about 3,300 tons.

In considering their defensive powers, we are struck with the small amount of surface exposed to the enemy's fire, as contrasted with the extent in the old style of wooden hulls towering up deck over deck, and even when the comparison is made with the broadside armor-clads. But this can be still farther reduced in time of action by admitting water into the space between the two bottoms, leaving little more than the breastwork and turrets above water; at the close of the engagement the bottom would readily be emptied by the pumps.

The system of construction employed is that known as the bracket-plate system; it was first used in the Bellerophon by Mr. E. J. Reed, who thus describes the object of this invention: "For saving weight, simplifying workmanship, and to add both to the strength and safety of the ship." One of its characteristic features, the adoption of an inner bottom, has been proved to be of great value in saving ships which have grounded on rocks, and which, but for this inner skin, must have been unavoidably lost. The cases of both the Great Eastern and Agincourt, than which there are no larger vessels afloat, show how highly it is desirable that every vessel should be thus built, so as to possess the additional element of safety in being still seaworthy when the outer skin is broken through.

The armor on the sides, of a depth of 7 ft., is worked in two strakes, the lower being 6 in. and the upper 8 in. thick, the teak backing behind being 11 in. and 9 in. thick respectively, the skin-plating behind this being $1\frac{1}{4}$ in. thick; these protective layers taper towards the extremities of the ship, thus diminishing the

weights at the extremities, and so decreasing the tendency to pitch and 'scend.

Rising 6 ft. 6 in. above the upper deck, which is level with the top of the armor on the sides, and giving a passage-way on each side of 5 ft. 6 in. wide, is built another structure termed the breastwork, 117 ft. long by 34 ft. wide, plated with armor 8 in. thick, except in the wake of the turrets, where it is 9 in., backed by 11 in. of teak and another inch of iron worked upon the frames. To complete the protection, between the breastwork and sides, the deck is covered with $1\frac{1}{2}$ in. of iron and 8 in. of teak. On top of the breastwork around the turrets the deck is protected by $1\frac{1}{2}$ in. of iron and $3\frac{1}{2}$ in. of teak, so that some provision is made against the plunging fire to which the decks must be very liable from being so little raised above the water.

Each ship has two revolving turrets enclosed within the breastwork; that portion of them which rises above it is covered with 9 in. thickness of armor, 11 in. of teak backing, and another inch of iron worked upon the frames of the turrets behind the backing; but in the vicinity of the ports, which are necessarily sources of weakness in the armor, the plating is increased to 10 in. in thickness; the top of the turrets is covered with 1 in. plates.

We must not omit, in this description of the defensive power, to mention the pilot-house, which towers 17 ft. above the breastwork, and is protected by 9 in. of armor, 8 in. of teak backing, and 1 in. of skin plating in thickness. This tower is of great importance in enabling the officer who has charge of the vessel to direct her movements at any time and under all circumstances.

Nearly 11 ft. above the breastwork is built a light deck, commonly known as the "hurricane," or "flying deck." On it are stowed the boats, chart-house, and upper steering-wheel; it insures safety and comfort to the watch while the ship is steaming ahead in bad weather. Care has been taken to keep the deck as short as possible—in fact, it but just overlaps the turrets at each end—so that, in case of the end supports being shot away, there is no danger of the turrets becoming jammed by the fallen structure.

For purposes of attack, each turret will carry two 18-ton guns, throwing 400lbs. projectiles. These missiles are too heavy to be carried by hand, and, therefore, overhead rails are fitted for transporting them.

The projecting prow with each monitor as fitted for running down an enemy, is considered, by naval architects of the highest repute, to be a most powerful means of attack, and the bow is strongly framed to enable the shock occasioned by running into an opponent to be the better resisted; for this purpose the longitudinal frames are extended to the stem, to which they are firmly attached. A collision bulkhead is fitted at the third transverse frame from the bow, so that in case of leakage in the fore-compartment, the vessel would still be perfectly safe.

Objection has been made to this mode of warfare, on the ground that the vessel attacking would be quite as liable to injury as the one she ran down; the example of the Amazon running down the Osprey being referred to in illustration of the evil effects, as both vessels sank. But in this case the Amazon was simply an ordinary lightly-built wooden craft with a wooden stem, and it cannot be accepted as evidence, to decide either way, when special preparations are made for the purpose of ramming. That this mode of attack is very destructive and could be safely employed, was shown in several instances during the recent civil war in America. But theory also points out that the shock to such a vessel by impact at a speed of, say $7\frac{1}{2}$ miles per hour, not an improbable one, at the time of collision, would be only equal to that caused by being struck with a 400 lb. projectile at a velocity of about 500 ft. per second.

These requirements are so moderate, that we are forcibly impressed with the conclusion that the projecting prow could be safely employed for such an encounter.

Both the turrets and capstan are worked by independent engines, but in case either of these for the turrets should be disabled, the turret could be readily turned by manual labor, as it pivots round a large hollow spindle firmly secured in the centre, and its weight is borne upon conical rollers under the periphery, each roller being connected by an iron rod to a metal-ring casting, which works round the hollow spindle previously referred to. The steering-wheels are also worked by steam, which seems to be an excellent plan, as the deficiency of steer-

ing power, so long severely felt, has been overcome, and provision is also made, if the steam steering gear should break down, to work in the ordinary manner by hand.

As the crew will be berthed below water, and access of air in the usual way is entirely out of the question, it is satisfactory to find that great attention has been paid to the ventilating arrangements, which are of a most elaborate kind.

In short, these vessels appear to be intricate machines containing a multitude of appliances for the numerous purposes that have to be carried on within them; and it is to be hoped that their merits and demerits, their capabilities and deficiencies, will be fully and fairly tested before any risks are incurred with them.

MECHANICAL FALLACIES.

From "Engineering."

There is a fashion in opinions as well as in clothes, and as we find the cast-off garments of the "upper ten" descending we know not how low, so also views long since discarded as untenable by scientific men still linger in the classes beneath them. Garments and ideas are both altered to suit the wearers, so much so, indeed, as not to be recognized at first sight. This has been the case with "perpetual motion," that will-o'-the-wisp which has constantly eluded the grasp of the inventor at the very moment of success, and has in many cases brought down his grey hairs with sorrow to the grave. It is very generally supposed that the belief in perpetual motion, like the belief in witchcraft, has died a natural death; but this is not the case. It is as flourishing as ever, but in a somewhat different form, and the title "improvements in motive power" covers any number of mechanical fallacies. The patent records furnish some instructive information on the subject, and we will take the year 1866 as an example. In that year 64 patents were granted for obtaining motive power, and twenty of these depend for their presumed action upon the simple principle that 2 + 2 is greater than 4. They are not only self-moving machines, but they supply power to drive others. It is quite unnecessary to mention them all in detail, but we may speak of a few of them. It is the old, old story. One "engineer" has a wheel provided at the extremities of the arms with flexible bags weighted at one end. The bags open and fill with air as they arrive at the bottom, and the air is forced out as the wheel brings the weighted end uppermost. A "mechanician" patents "a combination of levers and rods" fearful to contemplate, "whereby a greater amount of power is rendered available for use and aiding to overcome the resistance." Another inventor speaks of a "power-creating wheel" which consists of a wheel having a tube of vulcanized india-rubber secured on a portion of its outer periphery, the ends being connected with the hollow axle to which the wheel is attached. The other wheel has an elastic tube on the opposite portion of the periphery, so that one tube may always be undergoing compression. By this means a supply of compressed air is obtained, which, says the enthusiastic individual who proposes the plan, "is the power I use for driving or propelling such engine, carriage, or apparatus." One inventor proposes to gain power by means of a weight revolving at a high velocity, whilst another lays down this principle: "Any body being plunged in a liquid is submitted to two opposite forces; first, its own weight, which tends to lower it; secondly, the pressure of the liquid, which tends to raise it with a force equal to the weight of the liquid displaced by the body. The difference between these two forces" is the motive power which the inventor proposes to use. On the principle of "having one's cake and eating it," a weak-minded enthusiast attempts "to produce motive power by the force of steam acting on a reaction and direct action wheel, both, however, at the same time." In other words his machine consists of the toy known as "Hero's steam engine" combined with Branca's engine. Another equally greedy individual utilizes the force of the steam expended on the bottom and top of the cylinder during the up-and-down strokes of the piston.

"Which is effected by causing the steam cylinder to slide in the reverse direction to the piston." What, however, is most amusing, is the self-satisfied air of the motive-power man, when he condescends to argue. We will take, as an instance, the author of a machine, the name of which perhaps indicates to some extent the "cloudy" condition of the inventor's mind, and which is described in the specification as "an engine manufacturing a power," and of which it is stated that it "constitutes that desideratum so thoroughly 'tabooed' in its assumed impracticability of attainment, that scientific bodies have in instances determined to consider no such question"—and quite right too. The inventor then proceeds to develop his theory at length.

Sceptics are disposed of in the following short and easy manner: "To anyone not educated to the point of incapacity for such a consideration, the demonstration given above would appear amply sufficient. But as a rule the difficulties of surmounting an established creed, which has become a part of the being of its professor, are as insuperable as would be the difficulty of making an intelligent Christian out of an intelligent Mahometan."

We will give one more instance of the eccentricity of the inventorial mind. A patent was granted in 1864 (No. 2,811), for "improvements in developing heat, boiling water, and generating steam." It took two geniuses to accomplish the invention, the one a surgeon and the other a "gentleman." They propose to use a boiler surrounded by rubbers, worked in the first instance by an auxiliary engine. The friction of the rubbers against the boiler will, say the inventors, generate sufficient heat to boil the water and get up steam. So far, good. As a philosophical experiment, such an arrangement is by no means an impossibility. "When the power of the steam in the boiler before mentioned," the specification goes on to say, "is sufficiently developed, the machinery connected with it can be set in motion to secure a similar revolution of wheels or motion of blocks, and the fire in the small engine first mentioned may be let out, and the means used to create the primary motive power discontinued!" The surplus power obtained in this manner is to be applied to any purpose which may be desired. It is worthy of remark that the law officer who passed this patent was Sir Roundell Palmer, who, it should be noted, is strongly opposed to the existence of a patent law. It can hardly be said that he passed the present application by inadvertence, inasmuch as he actually ordered the description originally deposited by the inventors to be amended.

We are not just now advocating any change in the law, but we are justified in asking that two public servants, each receiving an annual income of from £5,000 to £6,000, shall do their duty, and that the solemn farce of protecting, year after year, the very same ridiculous "inventions" by an instrument under the Great Seal may be discontinued. It is only fair to say that the recent agitation for patent law reform has, in some degree, goaded the law officers into a feverish activity. In one case which lately came under our notice, an inventor mentioned that the principle on which his machine was founded was that enunciated in "Mariotte's Law," which he subsequently alluded to as "that well-known law." The law officer objected to this, struck it out of the specification, and said, "let us have nothing about 'well-known laws.' Put it in plain English, so that a plain man can understand it."

It is quite obvious to all unprejudiced minds that the legal and political qualifications of a law officer are of little use, when technical questions often of extreme difficulty and importance have to be considered. We trust that the Select Committee on Patent Law when dealing with the very delicate question of previous examination will bear these facts in mind.

The following recipe for the preservation of milk appeared in "Cosmos:"—To every litre of unskimmed milk previously poured into a well-annealed glass bottle, add 40 centigrammes (about 6 grains) of bicarbonate of soda. Place the bottle (which must be well corked) containing the milk, for about 4 hours in a water bath, heated to 90 deg. Cent. (194 deg. Fahr.) On being taken out, the bottle is varnished over with tar; and in that state the milk contained in it will keep sound and sweet for several weeks.

RAILWAY GAUGES.*

By R. F. FAIRLIE.

From "The Artizan."

I had the honor last year, of reading before this Association a paper upon "The Gauge for the Railways of the Future," in which I pointed out the capacities of narrow gauge lines, and showed how unfavorably our own railway system, as at present worked, contrasts with such lines when properly handled. The great truths I then put forward were too startling to be received without some degree of ridicule and incredulity; and although I announced them in the full conviction that sooner or later they would be fully acknowledged, I was then little prepared for the rapidity with which that acknowledgment has come. The report of the Imperial Russian Commission upon the Festiniog Railway, produced a similar inquiry on the part of the Indian Government. I had once more the satisfaction of attending a Royal Commission, appointed to investigate the question of narrow gauge; and the results obtained on the second occasion were as satisfactory as those on the first. In Russia, at the instance of His Excellency Count Bobrinskoy, His Imperial Majesty the Emperor commanded a line of narrow gauge railway to be at once commenced, and a number of my engines to be constructed, in order that the accuracy of all I had asserted on the subject, and had shown to the Commission upon the Festiniog Railway, might be proved upon a more extended scale; and that the exact value of a narrow gauge system, for national service, might be ascertained by the fullest tests of experience. The Association will, perhaps, pardon a brief digression, while I here place on record, as a matter of history, the eminent services rendered to the cause of narrow gauge extension by the Russian Commission, and also by Mr. Spooner, the engineer and manager of the Festiniog Railway. This little line, of only 1 ft. $11\frac{1}{2}$ in. gauge, was originally constructed for horse traffic; but was worked after a time by small locomotive engines, resembling, in everything but dimensions, those in common use in England. As thus worked, the traffic outgrew the carrying capacity of the line; and powers to construct a second track were actually obtained. At this conjuncture, Mr. Spooner had the sagacity to perceive the advantage that would accrue from the employment of my system of traction, of which he had read, and the determination to carry out his perception to a practical issue. I constructed for him the now well-known "Little Wonder" locomotive, and thus gave him, on his single line, two-and-a-half times the carrying capacity that he had possessed before. The second track was thus rendered unnecessary, and it has never been made. In the application of all novelties there must ever be risks of failure from unforeseen causes, and hence many, even when they recognize a truth, shrink from the responsibility of being the first to carry it into practice. The acceptance of this responsibility by Mr. Spooner, the opportunities that he thus afforded me of proving the working value of my principles, and the facilities for inspection and experiment that he has since courteously allowed, all fairly entitle him to be considered the father, as his tiny railway has certainly been the cradle, of the narrow gauge system of the future. The next step was made by the Russian Commission. It would be difficult for me to do justice to the infinite care and pains with which Count Bobrinskoy, the President of that Commission, investigated every detail before arriving at his conclusion, or to the earnestness with which he afterward pushed this conclusion to its legitimate results. In Russia, as in other countries, there are men whose interests or whose prejudices lead them to cling to existing systems, and the opposition which proceeded from such persons could only have been overcome by the strength of clear convictions, of unsullied integrity, and of indomitable resolution. Count Bobrinskoy was worthily assisted in his novel and important duty by the other members of the Commission, among whom I may name M. B. Saloff, Professor at the Technical School of Engineering, St. Petersburg; M. von Desen, now resident engineer in charge of the works; and M. Schoubersky, in charge of the rolling stock of the Imperial Livny Railway. To these

* From a paper read before the British Association.

gentlemen the entire civilized world owes a deep debt of gratitude. The line which was constructed and equipped in accordance with their report has now for several months been in operation. The results of its working establish all that I claimed for the narrow gauge; and the final official trials that will take place this month will determine the general adoption of the 3 ft. 6 in. gauge in Russia, together with the employment of my locomotives, without which the value of the narrow gauge at once sinks into comparative insignificance. This rapid action is due to the promptness with which His Imperial Majesty of Russia appreciates progress, to his freedom from prejudice, and to the fact that I have never advanced anything which I have not been able to prove. In India, although I believe ground has not yet been broken, a metre gauge has been decreed for general introduction; and the strongest advocates for the retention of the 5 ft. 6 in. gauge have been entirely defeated. In Australia, Tasmania, and New Zealand, narrow gauge railways have been undertaken, and will be built as fast as means that have been straitened and opinions that have been prejudiced will permit. In South America to a great extent, and in North America—I speak of the United States—to a marvellous degree, the reform I have so long, and at last so successfully, advocated,is making way with an astonishing rapidity. Some 2,000 miles of narrow gauge line are under construction; the great Denver and Rio Grande Railway, 850 miles in length, is being built upon the gauge I have made specially my own; and I may mention that this width of 3 ft. was decided upon by the President and principal officers of the Company after considerable investigation of the principles of my system recommended to their consideration by Mr. George Allan, C. E., who at an early period became strongly convinced of its advantages. A great transcontinental railway from the East to the Pacific is being organized, which, it is expected, will also be on the new narrow gauge. California is building similar lines; the Western States and Territories—pastoral, agricultural, and mineral—are building them; Massachusets, already covered with a network of ordinary gauge railways, is legislating for them; and many others of the Eastern States are earnestly considering the advisability of their immediate construction. As little as yourselves could I have last year imagined that all this progress would have been made in less than twelve months. At that time I was discouraged on almost all sides; I was hampered by the weight of prejudice and of opposition of every kind; but knowing I was right—knowing that the work I had in hand was one which would benefit the whole of the civilized world—knowing that, could I once produce conviction, there need be no country, however poor, that could not be traversed by profitable railways, I persevered, and to-day I find that my efforts have been crowned with a great and substantial success. Need I say that I appreciate this victory, counting the past pains as nothing, and being still more anxious to continue advocating the truth? But it is only due to this Association that I should state how much of my success I owe to its influence, and to the weight thus added to my now celebrated paper on "The Gauge for the Railways of the Future." To that paper I attribute a large proportion of the extraordinary activity that I have described. Stamped with the approval of this Association, the paper has circulated in all countries, and has been translated into all European languages, including those which have been naturalized in South America. It has formed the text for innumerable discussions; it is almost daily quoted in the journals of the United States; and it has excited the most lively interest among the railway engineers of that country, where existing management shows results still more discouraging than those which are obtained in England. The British Association, therefore, more than any other public body, has helped forward a vast reform, and gratefully feeling this, I am encouraged to come here again on this occasion. It is not long since, that to doubt established gauge was professional heresy. A type to which an accident had given birth, had come in course of time to be considered perfect; it was a superstition quickened into a religion. By degrees, after scores of thousands of miles of railway had been built, and hundreds of millions of pounds expended, it began to be seen that there was something still to be desired, and that it was ruinous to make railways for the service of remote districts yielding but small traffic, or in countries whose limited means and commerce could

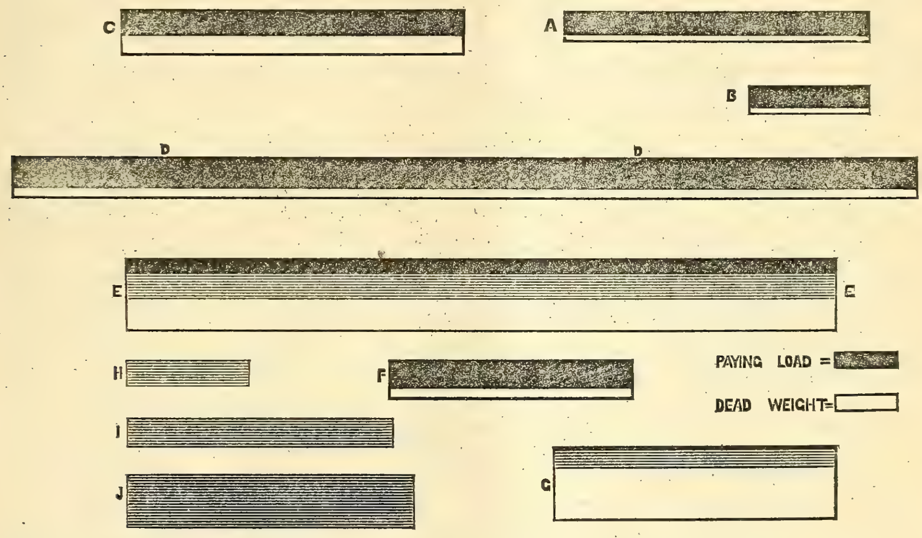
not justify large expenditure. By this time the great outlay which attended the labors of the earliest engineers — the outlay involved by heavy works to gain easy gradients—had been somewhat reduced, and with improved locomotive practice, steeper gradients and sharper curves became possible. Then came the very recent modification of making essentially light lines upon the standard gauge, conforming as much as possible to the natural contour—surface lines, as I was the first to name them in 1864. By adopting them the cost of construction was greatly reduced, and was brought somewhat more into proportion with the revenue to be derived. But these improvements were but improvements upon a bad type, and real reform could not be effected whilst the width of gauge remained, while the rolling stock continued unaltered, and the locomotive rested unmodified. Meanwhile, the history of railway construction in England was slowly repeating itself, even in an exaggerated form, abroad, and particularly in our colonies, where the primitive types were perpetuated by the pupils of the old school of engineers. And here I may remark that the difficulties encountered in this country in railway reform have been faithfully repeated in our colonies—an illustration of cause and effect. Gradually it became known that the ruinous practice of English engineers in Norway had forced the Government of that country to adopt an entirely new type, after the intermediate stage of light standard gauge railways had been largely tested and abandoned, and that for the first time a national narrow gauge system was established. But this was done so quietly, and information filtered so slowly from that isolated country, that until recently only a few have known of the change, and fewer have known, or have cared to inquire, about the practice followed or the results obtained. Of course, exceptional and independent lines of very narrow gauge, established almost universally for mineral traffic, have existed for many years; but these, with the exception of the Festiniog Railway, do not enter into the question; on the contrary, indeed, their small traffic capacities, as worked, have served the opponents of narrow gauge as arguments against innovation. So matters stood when I, having convinced myself of the monstrous errors which cripple our standard railway system, and having learnt the capabilities of narrow gauge—which are yet scarcely understood even by the engineers who are advocating and constructing them—so matters stood when I first devoted myself to the effort of promoting the general introduction of narrow gauge lines, and had the audacity to set myself up in opposition to long-established and deeply-rooted principles. At first, the utmost concession I could obtain—a concession granted but by a few—was that for new countries, where railways did not exist, or for poor countries, where traffic was light and uncertain, a narrow gauge system might be adopted with some amount of advantage; but that its capacity and consequent utility were proportioned to its gauge; and that hence, as a natural consequence, not only must such lines as I recommended be located in districts where only a very small business actually existed, but where also the prospects of its increase were extremely remote. I knew the error of this opinion, for I knew the actual capacity of narrow-gauge railways under proper management; therefore I was encouraged to persevere until, as the circle of conviction widened, I was enabled to put my views to the test of actual and wide experience, and to stir into life the radical reform which to-day is spreading on every side, and which shall before long become general.

I showed you last year how, upon a railway costing one-third less then a line of an ordinary gauge, I could with equal dispatch carry such a traffic as that of the London and North-Western Railway, with a saving of three-fifths of the dead load carried; and how in so doing I could effect a corresponding reduction in engine power, and consequently in cost of fuel, of rolling stock, of engine repairs, and of maintenance of permanent way. All this could be effected at a speed at least equal to the present speed of freight trains for the goods traffic, and at 35 miles an hour for the passenger traffic ; a rate which is but little below the average of the mileage made by fast passenger trains in this country. We are so accustomed to the present condition of things—or, perhaps, we are so ignorant of the real elements of railway economy—that it is difficult to believe this great reform possible; but belief was more difficult a year ago than it has since become, now that all my

statements have been proved to be incontrovertibly true. The question, however, is one of such radical importance, that I may once more devote a few words to its elucidation. On the London and North-Western Railway, the average practice is to employ 7 tons of wagon to carry 1 ton of goods, but I assume the proportion of dead weight to be only four to one, in order to make out as favorable a case as possible. The average weight of goods trains on the London and North-Western Railway is 250 tons; composed, in the proportions I have mentioned, of 50 tons of freight to 200 tons of rolling stock. (See diagram E E.) On the Livny (New Russian), (see diagram DD,) 3 ft. 6 in. Railway, on the other hand, the average gross weight of trains is 354 tons, or 104 tons more than that of the London and North-Western, while the dead weight is only 94 tons. This proportion is also shown on the diagram. To carry this paying load of 260 tons on the London and North-Western, 1,040 tons of wagons would be employed, or more than eleven times the weight required by my system. In all my arguments, I of course deal with general goods traffic only, exclusive of minerals. It may be urged against this comparison that the more favorable traffic conditions of the Livny Railway help the results; but it is sufficient to reply, first, that with the reduced gauge reduced weight of wagons in proportion to capacity is feasible; next, that the smaller wagon capacity is essential to economy; and third, that while rolling stock of the smaller class is certain to be loaded more nearly to its ultimate limits, the difference between the maximum load, and the absolute loads obtained in practice, are attended with none of the excessive cost inevitable on a 4 ft. $8\frac{1}{2}$ in. gauge. I would here call your attention to a most important fact in connection with railway goods traffic. The average load of merchandise carried by each wagon in this country is considerably less than 1 ton. Experience has proved that the exigencies of traffic in this country have settled this average, yet wagons of four times this capacity must nevertheless be provided. This fact of itself is sufficient to show that so broad a gauge as the standard one is very excessive. With a narrow gauge this evil may be prevented, and if a higher average per wagon could not be attained, at least a far lower proportion of dead weight would result. This I have endeavored to make apparent in the diagrams, which show the average proportions of dead to paying weight on the 4 ft. $8\frac{1}{2}$ in. gauge, and on the 3 ft. gauge; and I have also placed the load carried as the average by the standard gauge upon a train running on a 3 ft. gauge, the varying proportions being well expressed by contrasted colors. The great economy in working brought about by the causes enumerated above, would react upon railway business, and in increasing it would certainly raise the wagon average, because the cost of carriage would be so much reduced. I think you will agree with me that I am no visionary, but have always spoken within the mark, making my position sure as I advanced, and asserting nothing that I could not prove in actual practice. I have obtained, by the development of my system, results very closely approximating to those I stated last year—namely, three to one of paying to dead load, and I know that this proportion can and will be reached when my views are fully carried out, when a Fairlie gauge is worked with Fairlie locomotives and stock; while by no other system in existence can such results be obtained. In the report of the Royal Railways Commission, published in 1867, the following pregnant conclusions were arrived at from the opinions of the principal engineers and railway managers in this country: "The only way in which an increased receipt in proportion to the cost of running the trains can be anticipated, is in carrying a larger number of passengers in proportion to the number of passenger carriages in the train, and running the goods trucks full instead of partially full; or, in other words, obtaining a greater amount of work out of the engines and carriages than at present. But this means that the passenger trains would be less frequent and more crowded; that the passengers going on to branch lines would have to change carriages more frequently; and that goods would have to be retained until full truck-loads were made up, which would result in a slower delivery of goods." So that, as the necessities of traffic enforce frequent passenger trains, three or four times the necessary weight of carriages must be provided, and as goods cannot be detained until trucks are

fully loaded, it follows that universal extravagance is inseparable from the present system. Railway managers, who are, of course, thoroughly conversant with the subject, agree that our existing railways are at present being worked to the best advantage. If so, it cannot be doubted that there is a grave blunder somewhere; and if this blunder is not to be discovered in management we must seek for it in construction, and there we shall find it. We shall find that railways of the existing gauge will labor under disadvantage for all time ; they will remain oppressed by the curse of dead weight, an evil from which they can by no means be relieved ; dead weight in their rolling stock for passengers, one ton of which requires thirty tons to convey it ; dead weight in their rolling stock for freight, which can never be more than one quarter fully loaded, and dead weight in their locomotives, ill applied for obtaining useful results, but always destructive to the permanent way. Nor does increase of traffic upon a great standard-railway system tend to reduce this evil ; if it did, the London and North-Western Railway would not at the present time be expending enormous sums in doubling their permanent way. Experience shows that increased traffic does not diminish averages of weight ; for the fact that these averages were larger 20 years ago than they are at present, although the traffic had not then reached half its present dimensions, was simply because the wagons then averaged about a ton less in weight. With a double business, each wagon does carry twice the average amount that it carried 20 years ago ; but twice the number of wagons then employed carry each their usual complement of a single ton. There is, therefore, no escape from the conclusion that the existing proportion of dead weight to paying weight upon a 4 ft. 8½in. railway cannot be reduced, so long as the condition of things exists which guided the Railway Commission to its conclusions, but that it must remain a fixed quantity independent of increase of business on the line. I think no more striking illustration of the error of our present system can be conceived than is afforded by the daily practice of a magnificent company like the London and North-Western Railway; who, at the present moment, be it remembered, have commenced to double the width of their road through press of business ; yet who are sending out daily, and daily receiving, at Euston square, some 4,400 passengers, in carriages which contain sitting accommodation for 13,500 ; and who carry their enormous freight in increments, averaging less than 1 ton, in wagons having six times their capacity. Imagine the amount of capital sunk before this result was obtained! Conceive the waste of engine power, the wear and tear of rolling stock, the destruction of permanent way, the cost of staff, all entailed by this curse of dead weight ; and then imagine how easily all this unmechanical and unbusiness-like state of affairs might have been prevented by the simple adoption of a suitable rolling stock running on a suitable gauge ! I am not for a moment advocating any radical change in our English railway system ; that system has outgrown the season of radical reform, and we must make the best of it as it is ; but I seek to prevent the repetition elsewhere of mistakes that have been so costly here. I want to prevent the unnecessary extension of a system that is palpably false, but which is not on that account the less strongly defended and protected. That our great error was known some years since to all thinking engineers, is shown by the quotation I just now made; Mr. G. P. Bidder stated before the Royal Commission : "That great economy may yet be obtained in the transport of minerals over long distances by means of railways laid out under conditions admitting of very long trains being run." In this statement I find the very essence of the question at issue between myself and all conservative engineers ; I find the necessity of reform acknowledged, and the means of attaining it hinted at by my warmest opponent. Except that his views did not extend to passengers and goods, but were confined simply to the transport of mineral traffic, we have a complete statement of the problem which I have brought successfully to a solution. The requirements which Mr. Bidder hinted at generally, I have worked out in detail, and have extensively reduced to practice, with results that show his judgment to have been sound so far as it went. The conditions under which a railway should be laid out to meet these requirements, are clearly not those which

rule the present system; ample experience proves the contrary, showing that no line, however full of business, can be worked to its full capacity. We are led, then, unmistakably, to a narrow gauge, to the adoption of passenger carriages which shall be filled, or wagons which shall be almost fully loaded, and of weight which shall bear a reasonable proportion to their capacity, and we are led to the adoption of very long trains and powerful engines. Considering the date of Mr. Bidder's opinions, they could not have been put more clearly or more concisely. To a certain extent, but in a very limited and imperfect degree, experiments were made in the direction indicated—faint foreshadowings of the practice now being so widely introduced—by an attempt to convey extremely heavy trains by means of an auxiliary pair of cylinders placed under the tender of the engine, and receiving steam from the boiler; the idea being, to utilize all the available weight of engine and tender for adhesion. In running expenses, the results of these trials were very satisfactory, showing a large reduction of cost in carrying the heavier load. There were many reasons why this arrangement should prove unsatisfactory, but I quote the results obtained, because they will not be called in question, and because if so much economy could be obtained by such a contrivance as the steam



[The foregoing diagrams represent various proportions between dead weight and paying load, on railway rolling stock, as follows]:

A shows the average load carried in daily practice by the Fairlie engine "Little Wonder" over the Festiniog Railway, 1 ft. $11\frac{1}{2}$ in gauge, the average up grade being 1 in 92. The engine weighs $19\frac{1}{2}$ tons, the weight of load is over 107 tons, and the proportion of paying to non-paying load is 3 to 1.

B shows the average daily working of the ordinary engine, weighing 10 tons. The load carried is a little in excess of 43 tons.

[The above diagrams show very clearly the capacities of the Festiniog Railway after and before the adoption of the Fairlie engines on it.]

C shows the maximum load of 120 tons carried by the most powerful engines on the 3 ft. 6 in. Norwegian Railway up gradients of 1 in 90. The proportion of paying to dead weight is 1.6 to 1.

D represents the daily working of the freight train of The Imperial (Russian) Livny Railway, 3 ft. 6 in. gauge, up gradients of 1 in 80. The gross load conveyed (exclusive of engine) is 354 tons, of which 260 tons are paying weight. The engine weighs 42 tons, and the proportion of paying and non-paying loads is 2.78 to 1.

E represents the actual ratio between dead and paying loads conveyed in a 250-ton goods train on the 4 ft. $8\frac{1}{2}$ in. gauge; the lighter tint indicating the maximum capacity of the stock, giving 1.8 to 1 of paying to dead weight.

F shows the weight of a train on the 3 ft. gauge carrying the same paying load, 50 tons, as that conveyed by the wagons on the 4 ft. $8\frac{1}{2}$ in. gauge, as shown in the previous diagram.

G is a diagram showing the existing ratio, between dead and paying weight, on passengers train, 4 ft. $8\frac{1}{2}$ in. gauge, as well as its maximum capacity, being 30 to 1 and 3.3 to 1 respectively.

J, H, I, are diagrams showing the comparative dead weights of trains on the 4 ft. $8\frac{1}{2}$ in., 3 ft. 6 in., and 3 ft. gauges respectively, employed to carry 50 tons of paying load, every wagon of each train being loaded up to the present average weight of 1 ton per wagon.]

tender, I may at least claim proportionately advantageous results for the system of which this was an indication. Thus, with an ordinary engine, the cost of conveying a load of 210 tons was 20d. per mile, whilst the cost of conveying a load of 310 tons by the aid of the steam tender was only 23d. per mile. It is obvious that no such saving as this could have been effected had two independent engines been employed upon the same duty. The results clearly prove that a large saving can be effected by increased engine-power and greater loads ; but, as I have already pointed out, this economy cannot be realized on railways of the standard gauge; but on the many thousand miles of narrow-gauge railways that will before many years be constructed, the true system of economical working, developed by me, will not only be possible, but will be universally acknowledged and adopted. It would seem a very simple and self-evident fact, that the means of conveyance should be fairly proportioned to the amount to be conveyed, and yet I have been laboring for years to make people understand this. One would think it would be sufficient to point out, to countries contemplating the construction or the great extension of railways, and looking to England and English practice as a model, that the best labors of our engineers, after thirty years' experience, have given us a railway system on which it is necessary to have 4 tons of wagon for every ton of goods, and from 10 to 30 tons of carriages (see the diagram G) for every ton of passengers. And, indeed, abroad it is pretty widely understood, that it can only be on a narrow-gauge railway that a full measure of usefulness can be obtained, and a proper proportion between paying and non-paying load can be secured;—this is because, the amount of engine power being unlimited, better paying trains can be carried on the narrow than on the broad gauge; the difference arising from the fact that the dead weight required for the transport of passengers and goods is reduced in the manner shown by practice and indicated in the diagram. The reform in effected by the adoption of a suitable rolling stock, in which dead weight is kept down by the smallness of the gauge, but in which ample capacity is obtained. Such carriages and wagons exactly meet the difficulty which is one of the great causes of dead weight on a 4 ft. $8\frac{1}{2}$ in. gauge—namely, the necessity of transmitting passengers and goods, whenever practicable, to their destination without change of vehicles. With the small carriages and wagons, the expense attending this proceeding is reduced to the lowest possible cost, because, though vehicles of appropriate capacity can be employed, and each can be loaded almost to its full complement of passengers or goods, carriages half or two-thirds empty would never form necessary accompaniments to a train; and even if it were not possible in practice to place a larger share of the load in each vehicle than the present average we should have wagons of 5 tons capacity weighing $1\frac{1}{2}$ tons, instead of others weighing 4 tons to carry the 1 ton average. This capability of subdivision of traffic is one of the most important advantages which the narrow gauge offers; it involves the leading principle in railway economy, but it is an economy which I have shown—and I am borne out by all the weight of the evidence given before the Royal Commission—to be impossible on the broad gauge. But it must be remembered—and this is a point not understood by some of the strongest advocates of narrow gauge—that such lines are of but little avail, unless they are provided with suitable locomotive power. If a line is made in all respects a miniature copy of a broad-gauge railway, with miniature rolling stock and miniature engine, its utility decreases, and its working capacity goes down, but its working expenses go up. In illustration of this I may quote the results of Norwegian practice, where one of the narrow gauge line, carrying only a very small traffic as compared with that conveyed upon a broad gauge in the same country, shows its expenses to be out of all proportion ; while the percentages of the expenses to the receipts vary from 65.47 to 103.5 on the various narrow gauge lines now built in Norway, a result that cannot be considered favorable. If we look at the capacity of the engines on these railways, we shall see that they are capable of drawing besides their own weight, 83 tons, 55 tons, and 84 tons respectivelly, up gradients of 1 in 70, 1 in 42, and 1 in 60, and it is worth noting that the proportion of working expenses to receipts decreases as the power of the engine increases. Although many other causes besides those of mere lo-

comotive expenditure step in to interfere with results, the regular proportion is, I think, too clearly marked to be independent of this most important question. The capacities of the Norwegian stock and the maximum trains conveyed by the engines are shown in the diagram. I refer again for a moment to the results obtained by the employment of the steam-tender for dragging great loads. Mr. Sturrock found that he could, by adding a pair of steam cylinders to the tender of a locomotive, convey trains weighing one-half as much again as the maximum load carried by ordinary engines, with an extra expenditure of about 15 per cent.; and a train of any given weight can be conveyed for from 64 to 70 per cent. of the cost of such train divided into two equal parts, which means a saving in the locomotive accounts of from 30 to 36 per cent. It is argued against me, that an engine of my system is no more useful or profitable than two engines coupled together. My experience proves the contrary; so far as they go, the results with Mr. Sturrock's contrivance bear me out, and so do the results obtained by the working of MM. Moyer's engines (adapted from my own) in France. If such a system as that which I recommend had been introduced into Norway, it is needless to point out that a considerable modification of the balance sheet would have been the result. To sum up, then, the requirements necessary for making a narrow-gauge railway perfectly efficient, we must have light, small stock, easily handled, and very powerful engines, capable of drawing heavy loads. The experience of the present year entirely bears out this assertion. We need only turn to the 3 ft. 6 in. Livny railway in Russia, carrying regularly its 354 tons of train exclusive of engine, a duty accomplished by one Fairlie locomotive without distress to the permanent way, and up gradients, some of which are 1 in 80, of 4 or 5 miles in length, and with an economy shadowed forth long since by the crude appliances that were tried with a vague hope of achieving a similar result. Again, as already stated, the introduction of the same system on the Festiniog Railway avoided the necessity of doubling the line of rails (a work which was actually commenced so far as preliminaries were concerned), by more than doubling the utility of the single pair. The diagrams show the change very strikingly, the one indicating the daily duty of the "Little Wonder," the other the similar duty of the ordinary engines of rather more than half the weight. It now remains to point out as briefly as possible the circumstances that have led me to adopt a 3 ft. gauge, and to recommend that width for general introduction. Experience has shown that 3 ft.6 in. can be made a highly economical and efficient width, but it does not by any means follow that it is the most serviceable and most efficient, any more than it follows that the accidental 4 ft. 8½ in. was all that could be desired, even though an Act of Parliament had made it an article of belief. On the contrary, as our knowledge and experience increase, we are enabled to approach more and more nearly to that happy mean, on either side of which is error. While, on the one hand, there is every necessity for obtaining such a gauge as will afford a good and useful width of vehicles, on the other it is necessary to avoid such narrow limits as would necessitate the introduction of too great overhang on each side of the rails. The 3 ft. gauge appears to me to comply with all the necessary conditions better than upon any other, and it is from mere theorizing that I lend all the influence I have towards its adoption. There is a certain amount of saving in first cost as compared with the 3 ft. 6 in., not a large amount, but worth considering. This, however, I leave out of the discussion for the present. The all-important matters are to place upon the rails a thoroughly efficient stock that shall possess a maximum of capacity and a minimum of weight, and to supply engine power under the most economical circumstances, and I hold it to be easier to accomplish these objects on the 3 ft. gauge than upon any other. I am led to this conclusion both by a comparison of the actual work done on the 3 ft. 6 in. gauge, with that which can be accomplished with the 3 ft. gauge, and because, having in view the practical requirements of goods traffic, I find that I can obtain an ample floor area with less dead weight than can be secured by any other width; on a wider gauge the dead weight increases, on a narrower one the capacity decreases. A statement of the actual results of comparison will explain this more clearly and more quickly than could be done otherwise. On

the Queensland 3 ft. 6 in. Railway, the composite passenger carriages are 6 ft. 6 in. wide, and 6 ft. high inside. The capacity is equal to 34 persons, and the weight is 10 tons 500 cwt., or 600 cwt. per passenger; the second and third class carriages accommodate 48 persons, and weigh 9 tons and 2 cwt., or 3.75 cwt. per passenger. The wagons average 14 ft. in length, 6 ft. in width, and weigh 3 tons 5 cwt. The covered wagons are 6 ft. high inside, and the open wagons have sides 30 in. high; the first would have a capacity of about 7 tons, the latter of about 5 tons, the respective proportions of paying load to weight being 2.15 to 1, and 1.54 to 1. On the Norwegian 3 ft. 6 in. lines, the first class carriages are 6 ft. 10 in. wide outside and 20 ft. long, weigh 4.6 tons, and carry 32 passengers, the proportion of weight per passenger being 2.9 cwt; the second-class carriages have the same length and width, and carry 32 persons and weigh 2.4 cwt. per passenger. The covered goods wagons are 18 ft. long, 6 ft 7 in. wide outside, weigh 3.7 tons, and carry 5 tons, the proportion of freight per ton weight of wagon being 1.2; this proportion is steadily maintained throughout the wagon stock, rsing, however, as high as 1.6 to 1, while some of the more recent stock carries 6 tons instead of 5; of the increase of dead weight in these I have no data.

For a 3 ft. gauge, the stock that I construct is as follows: for first-class passengers the carriages are 18 ft 6 in. long, 6 ft. 8 in. wide inside, seating 18 passengers, and weighing 3 tons 5 cwt., or 3.6 cwt. per passenger. For second-class, the carriages are 16 ft. 6 in. long, 6 ft. 8 in. wide, weighing 3 tons, and carrying 24 passengers, being 2.5 cwt. per passenger; the third-class carriages are of similar size, but seat 30 people, the dead weight being 2 cwt. per passenger. It will be noticed that these proportions are nearly identical with those of the Norwegian lines, but considerably less than those of the Queensland Railway.* My open wagons are 10 ft. by 6 ft. 6 in. by 2 ft. 10½ in. high, weighing 28 cwt. 3 qrs., and having a cubic capacity of 4 tons, equal to a proportion of 3 to 1; also others for light goods, such as cotton, are 14 ft. by 6 ft. 6 in., with posts and rails 6 ft. 6 in. high from floor, or, as we are now running them in Mexico, with a low ledge running all round only 6 in. high, on which cotton bales are piled in a similar manner to that on a street wagon or Lorry and covered with tarpaulin. The covered wagons are 10 ft. by 6 ft. 6 in. by 6 ft., of 360 ft. contents, and weighing 33 cwt., equal to 3 tons of carrying capacity to 1 of dead load. In all this stock, as well as in the other classes required, the centre of gravity is kept low, and an angle of stability of 38 deg. is in all cases maintained. It will thus be seen that upon a 3 ft. gauge I am enabled to place stock of ample size and of less weight than can be done on the 3 ft. 6 in. lines. In adopting this stock, I secure several advantages inseparable from the Fairlie gauge. The principle of these is: the reduced widths between the sole bars for the under frames of wagons and carriages, and lengths of wheel centres; these in turn affect the scantlings of material, the weight of the wheels, the size of axles, to carry certain loads. It has been argued that the excess of strength over the actual requirements for carrying, but necessary to resist the shocks and concussions incident upon shunting, etc., would not be affected by the gauge; and that if the gross weight of a train is maintained upon the narrow, that is now worked on the broad gauge, the wagon frame and coupling must be alike in weight to give equal strength to withstand sudden shocks and strains. Of course this is in itself quite true, and certain parts must be as strong in a train of given weight on a narrow as on a broad gauge. The force of the argument falls to the ground, if we remember that under present circumstances an average goods train, say of 250 tons, has only 50 tons of paying weight, the remaining 200 tons being stock Now, on the narrow gauge, supposing that only 1 ton of goods was carried per truck, as in the case of the 4. ft. 8½ in. gauge, the dead weight required to carry it on my system would be only 87½ tons, making the total weight little more than half, and reducing the force of shocks upon the train in a proportionate manner, so as consequently to reduce the requisite weight of parts. Take, now, this same weight of paying load in a train, namely,

*The stock here described is on the type used in this country; a different type would require to be made to suit different tastes, as in America for instance, carriages should have a central passage and rest on two bogies or trucks, with entrances at each end.

50 tons, and place it in the same portions in the wagons of the Norwegian 3 ft. 6 in. line, or in those of the Queensland Railway, and we shall find that the dead load carried runs up to 185 tons, or a close approximation to our English practice. Probably, therefore, this stock as built is not too heavy to resist the strains and shocks thrown upon it by reason of its own weight; but by the mode of coupling employed on the Fairlie stock, the destruction arising from the shocks caused by sudden stopping and starting of the trains, especially when shunting, is entirely avoided; and as the strength and consequent weight of the present stock depends on the necessity of resisting these shocks and bumps, it follows that the instant these are removed, the necessity for all this extra strength and weight is removed also. The foregoing figures really mean that to carry 50 tons of goods on the Norwegian or Queensland 3 ft. 6 in. gauge, the proportion of 1 ton per wagon being preserved, 92 per cent. of the weight of rolling stock used on the 4 ft. 8½ in. gauge would be required, as against only 43 per cent. on a 3 ft. gauge; showing a saving of 47 per cent. on the latter, as compared with the 3 ft. 6 in., as shown in the diagram. Of course, if the wagons were loaded up to full capacity, these percentages would be very much changed. It is to this point especially that I wish to direct your attention, as upon it the economy of the 3 ft. gauge rests. Whatever saving may be effected in the first cost may be lost sight of, the great advantage lying in the saving effected in working expenses. Every ton of dead weight saved goes towards securing the prosperity of the line, and if we can obtain the ample platform which the 3 ft. gauge gives, combined with so much saving in weight, there is nothing left to be desired.

In making my comparison, I have taken matters as they exist in Queensland and in Norway. The able engineers of those lines have designed their stock as economically as they found possible. I should have thought the dead weight might have been reduced to a certain degree; but of course I am aware that no such reduction as may be made on a 3 ft. gauge could be achieved.

Before I conclude, I may refer to one or two prevailing errors which exist with regard to the narrow gauge, and which are often urged against it. It is said that with a 3 ft. or 3 ft. 6 in. gauge, a far larger amount of siding and goods shed accommodation is required. Is it not sufficient to point out, as the wagons carrying the same on the latter as on a wide gauge are but some 10 ft. long, as compared to 16 ft., that a train of the former, conveying the same loads as one on the latter, would have but ⅝ths of its length? Here, again, the axion of subdivision of traffic is applicable in all its force.

Again, a common notion—and one that was strongly urged when the discussion concerning India was in progress—is that narrow-gauge railways may be constructed in difficult and hilly countries, but not on level and favorable ground. Doubtless this idea has grown from the fact that the saving of construction in the former localities is greater than in the latter. But, as I have already stated, the economy in the cost of construction is altogether subordinate to the greater and constant economy in daily use. The fact is that narrow-gauge lines are useful everywhere, are needed everywhere; the saving in their first cost rises and falls with the country over which they pass, and, always considerable, is greatest where precipitous districts demand lines that creep around and up hillsides; but the subsequent economy is not variable; it is always what I have shown it to be, when narrow-gauge railways and their equipments are worked, as everything should be worked, with a view to progress and development.

INTERNAL TEMPERATURE OF THE EARTH.

From "The Mining Journal."

It had been arranged that from the commencement of the Alpine Tunnel, observations of the temperature, at intervals of 1 kilometre (3,281 ft.), should be taken at both ends during the progress of construction. Signor Borelli, the resident engineer at the Italian side, undertook and carried out these observations very

perfectly on his part of the work; but, unfortunately, his colleague at the French end very soon lost interest in the matter, and such observations as were made were not recorded. Thus, the opportunity of comparison of two independent sets of observations, which would have been of very great value, has been lost, and this is the more to be regretted because the present data, in many respects, do not correspond with our previous knowledge of the rate of increase of heat as the distance increases from the earth's surface. The dimensions, etc., of the tunnel have been already before our readers; but, for better comprehension, we repeat them here. The total length of the enclosed boring is 40,140 ft., and the highest point of the mountain in a vertical line above it is 5,280 ft.—this point being 21,156 ft. distant from the Italian end. The rocks through which the tunnel has been driven consist, for the most part, of calcareous schist, partly talcose, and containing many bands and strings of quartz. The whole of the Italian work consisted in piercing through rock of this kind, and the same rock was met with at a distance of 11,000 ft. from the French side. All the rocks traversed are metamorphic, being, however, stratified, dipping at an angle of 50 deg., or thereabouts, to the northwest, and corresponding in age to the secondary rocks of England, from the Oxford clay to the Rhœtic, inclusive. The excavation of the tunnel from the Italian end was suspended when 6 kilometres (about 20,000 ft.) had been completed, being rather less than half way; but as the excavation from this end had been much more rapid than it had from the other, a small heading was continued to the distance of about 3,000 ft. further, when the French work from the other side was met. On the opening being completed a rush of air took place, driving the smoke of the last blast rapidly before it and towards the Italian end. It may be assumed that the tunnel will act as a kind of chimney—and that ventilation will be much assisted by an upward current of air, when it is considered that its Italian end is 4,241 ft. above the sea level, whilst the northern or French end is only 3,806 ft.—being a difference of 435 ft. in favor of a natural ventilating current. The following statement is a translation, by Prof. Ansted, of that published by Signor Giordano, who has tabulated the observations of Signor Borelli:

No. of observations.	Distance from S. entrance. Feet.	Temperature. Air. Fahr.	Temperature. Rock or water. Fahr.		Depth in feet.
1	1312	50.9°	51.8°	Small spring.	
2	1640	50.9	57.6	Boring from a heading 24 ft. from the wall of the tunnel..........	1500
3	3281	59.5	62.6	Boring of 16 ft. from heading..........	
4	3675	59.5	62.6	Small spring..........	
5	6562	64 0	67.0	Boring of 10′ from heading, 21½′ from wall...	
6	8202	64.0	68 0	Small spring..........	1700
7	9266	64.0	68.0	Small spring..........	
8	9843	68.5	73 0	Boring similar to No. 5..........	
9	13124	73.4	74.5	Boring similar to No. 5..........	
10	16404	76.1	81.5	Boring similar to No. 5..........	3000
11	19686	80.2	84.0	Boring of 10′ in a recess 13′ from wall, near the point where the excavation was suspended..........	4500
12	21156	86.1	85.1	Boring of 7′ under the culminating point of mountain. Small heading 7′ from wall..	5280
13	21858	86.2	82 4	Small spring.	
14	22967	77.0	80 6	Boring of 7′ into wall of small heading..........	4750
15	22993	77.0	77.9	Small spring.	

From this table it appears that the observed difference of temperature of the rock between the distance of 1,640 ft. from the entrance and the distance of 21,156 ft. is 27.5 deg. Fahr., the difference of depth beneath the surface in that distance being about 4,600 ft. If we allow for the increase of temperature of the

air due to the number of men employed, and the frequent blasting, the difference may be more safely estimated at somewhat less. The true maximum temperature of the rock may be taken at 84 deg. Fahr., and the part of the tunnel having this permanent temperature is 4,250 ft. above the sea, the corresponding point of the surface vertically above it being 9,530 ft. above the sea. The difference of the levels is, therefore, 5,280 ft. Mr. Ansted believes that a careful estimate of the distribution of the mountain mass would show this to be somewhat in excess of the true difference, and that if the slope were perfectly even, the difference of level would be about 5,080 ft. The mean temperature of the air decreases in ascending to the higher parts of the atmosphere at the rate of 1 deg. Fahr. for each 317 ft. of ascent, and the stratum of invariable temperature in descending into the earth is nearly 2 deg. Fahr. warmer than the mean temperature of the air at the surface. The city of Turin is 820 ft. above the sea, and its mean temperature 54.5 deg. Fahr. The difference in level between Turin and the highest point above the tunnel is 8,710 ft.; this, divided by 317, gives 27.5 deg. Fahr. as the amount to be deducted from 54.5 deg. Thus, the mean calculated annual temperature at the surface of the highest point above the tunnel would be 27.5 deg., and adding 2 deg. to this, the calculated temperature of the stratum of invariable temperature would be 29.5 deg. Fahr. Estimated in this way, the difference of temperature between the mean temperature of the air on the assumed surface above the central point in the tunnel, and that point would be 84 deg. -27.5 deg. $=56.5$ deg. Fahr., and the rate of increment (the difference of level being 5,080 ft.) 1 deg. in $(\frac{5080}{56.5})=90$ ft. nearly; or, assuming the stratum of invariable temperature to be 80 ft. below the surface, 1 deg. in $(\frac{5000}{54.5})=91$ ft., thus showing a very considerable variation of result as compared with most other observations that have been made in Europe and elsewhere at various levels. Signor Borelli's observations, tabulated according to these calculations, yield the following figures:

Observation.	Distance from S. entrance—Feet.	Depth from surface—Feet.	Temperature.	Rate of increment.
3	3281	1700	62.6°	1° Fahr. in 43 feet.
5	6562	1700	67 0	" 50
8	9843	1700	73 0	" 61
9	13124	1700	74.5	" 63
10	16405	3000	81.5	" 65
11	19686	4500	84.0	" 84
12	21156	5280	85 1	" 91
14	{22967* 18345*}	4750	80.6	" 93.4

* Feet from N. end.

NEW SURVEYING INSTRUMENTS.

From "The Iron Age."

Much attention has recently been drawn to a new form of instrument, which may be seen in Div. III. at the London International Exhibition. It is intended for gener l surveying, and from the inspection of it practical men are inclined to believe that it is very likely to supersede the ordinary kind of instruments employed for such purposes. It is the joint invention of Mr. H. D. Hoskold, of Cinderford, mining engineer, and Mr. J. E. Winspear, of Hull, optician and mathematical instrument maker, and they have designated it by the name of "Angleometer." It is particularly designed for measuring angles in the field and underground, similar to a theodolite, but in consequence of its peculiar construction it is not liable to the same amount of derangement and imperfection as that instrument—indeed, it will be found vastly superior, both in point of construction and working, and occupies

much less space. The instrument when made with a divided limb of 5 in. diameter is only $6\frac{7}{8}$ in. in height, and moreover, it is mounted with a telescope $10\frac{1}{2}$ in. in length, of high optical power, and is made to revolve vertically, and thus becomes a transit instrument of great power and capability, either for extensive surveying on the surface or underground. Furthermore, its particular form renders it well adapted to be used as a zenith telescope for performing astronomical operations of importance, and for connecting underground surveys to those made on the surface directly, by means of the telescope without magnetic bearings, rendering it for that one operation alone a most valuable instrument, which doubtless will duly be appreciated by mining men.

The whole arrangement is new, although there are some parts in it common to all superior surveying instruments, such, for instance, as the silver limb for receiving the graduations, parallel levelling plates, clamp and tangent screws, etc. In surveying instruments of the best class hitherto constructed, such as the transit theodolite, equal power and capabilities can only be obtained by additional height, weight and cumbrousness of parts, the subject of so much objection to their general introduction for mining purposes. Thus, if we take a transit theodolite, with a limb of 5 in. diameter and a telescope of $10\frac{1}{2}$ in. in length, as an *example of comparison*, it will be seen that the telescope must be mounted upon Y's, which would render it over 12 in. in height at least, besides possessing the disadvantage of having the magnetic compass very much smaller than its own limb. Every additional inch to the height of an instrument of this class proves a disadvantage, simply because all the centres and bearings must be longer, and, consequently, vibration of the parts is increased. This is more especially so when exposed to currents of air and wind on the surface, which prove very destructive to observations. It is, therefore, desirable that all these points should be kept well in view while designing an instrument. We are pleased to observe that this has been practically realized in the designing and construction of the angleometer. It appears that the length of the telescope does not regulate the height of the instrument, as in the class of transits before referred to, for a small instrument of the new type may be made to carry a telescope of equal length and power with those of some of the larger instruments of the old type, without additional height.

It will be seen by referring to the instrument in the Exhibition, that the horizontal axis carrying the telescope and vertical circle is mounted close down on low bearings, not more than $1\frac{1}{4}$ in. in height on the upper vernier plate. These bearings, axis, and all other internal arrangements, are covered up by a magnetic compass box of the same diameter as the angleometer's graduated limb. The needle of this instrument is constructed to carry a silver floating circle with verniers at each end, and it rests on a recess cut in the edge of the inner divided circle; it is thus prevented from rocking or vibrating unduly. The needle by its verniers is capable of reading magnetic bearings, to single minutes, and will prove of very great service for determining the magnetic vibration of the compass by observation. The divided limbs to horizontal and vertical circles are graduated to 20 sec., but it is intended to divide a 5-in. to read to 10 sec.; and by the high optical power applied in the telescope to render the instrument available for extensive operations, which were formerly performed with instruments of a large and more cumbrous nature. The telescope is fixed in a stout cylindrical ring, screwed to the one end of the axis a little larger than itself, and made to rotate in it horizontally, for the purpose of collimation. The vertical circle is constructed with a conical limb, and the graduations are put on its edge, instead of, as usual, against the side of it; there is, consequently, greater facility provided for reading angles off from it. This vertical circle is attached to the opposite end of the telescope axis, and balances and moves with it; consequently, no vibration whatever exists in the instrument, not even when exposed to a rather severe blast of wind. At the eye end of the telescope there is a perforation, into which a piece of glass is fixed nearly opposite the cross-hairs, for the purpose of illuminating them by means of the flame of a candle or lamp when the instrument is used underground or at night. At other times a slide is turned, which effectually shuts out all light. There is also a micrometrical arrangement work-

ing mechanically in the eye end of the telescope, and communicating with two circular discs, about $1\frac{1}{4}$ in. in diameter, outside the telescope, the circumference of which is divided into a certain number of equal parts, reading by means of verniers to the 10,000th part of an inch.

The object of this arrangement is for the purpose of ascertaining distances without direct measurement, which is performed in a very simple and accurate manner. There are two cross spirit bubbles fixed below the needle in the compass box, and on a level with the face of it; they are adjusted by means of screws, which do not appear, and cannot be damaged from exterior influences, as in theodolites. A longer and more sensitive spirit bubble is attached to the verniers to vertical circle, which are dead fitted, but adjustments are provided for the bubble. A lever clamping apparatus is also attached to the vertical circle, which acts more effectually than clamping screws of the ordinary form. As angles are measured from the side, and not from the centre of the instrument, special station staffs are provided, which, in practice, works out in the same manner as though all the angles were measured from the centre of the instrument. Lamps on a similar principle are provided for underground work. The inventors of the angleometer propose to apply its principles to all and every kind of surveying instruments.

It has been applied by them to an ordinary miner's dial, one of which may be seen in the London International Exhibition, and it appears to be an excellent little instrument for the purpose for which it is intended. It has plain sights at one side of the compass box, screwed to a horizontal axis passing through low bearings, as previously mentioned in the angleometer. To the other end of this axis a semicircle is attached, and graduated on silver to read to 3 min. It will be observed, on examination, that these plain sights may be made to perform an entire revolution vertically, carrying with it the horizontal axis and semicircle at the other end of it ; thus an angle may be observed at a high elevation or depression up to the vertical, in fact, or 90 deg., and in such position the sight does not interfere with reading the face of the compass. The best construction for dials hitherto has been known as Hedley's dial, but when the concentric ring of it is raised, and the sight applied to a high angle, both the sights and ring carrying them tend to prevent dispatch in reading off bearings. All these disadvantages are avoided in the construction of the new dial referred to.

The plan of connecting lines without bearings can also be performed by this dial directly by its sights in awkward places underground, where the vertical distance of connection is not too far for marks to be seen distinctly through the blank sights. Bubbles are also fixed on a level with the compass face, so that vertical angles may be measured from the semicircle to a considerable degree of accuracy. The proprietors of this invention have applied for a patent, which will very soon be completed.

It is understood that the same parties have another matter on hand, and in course of construction, which could not be completed in time for the Exhibition. This refers to a universal plotting scale, for laying down base and other lines to very great niceties.

ON THE CONSTRUCTION OF TRACTION ENGINES.

From "The Engineer."

The traction engine, or common-road locomotive, was invented before the railway locomotive. The traction engine in its best form is still a very imperfect machine. The railway locomotive, on the other hand, is unsurpassed in beauty of workmanship and efficiency by any other species of steam engine. How are these facts to be explained ? It cannot be disputed that the general principles which guide engineers in designing locomotives apply to a great extent to all forms of the steam engine. We require a good boiler to generate sufficient steam ; a good arrangement of machinery to utilize the steam generated. These truths should be self-evident. They are invariably acted upon by locomotive superintendents with the happiest results. We find them frequently disregarded by builders of traction

engines with the worst possible consequences. No one ever hears nowadays of a locomotive which will not keep steam. A breakdown on our railways is, as regards the locomotive, a strictly exceptional occurrence. We wish it were possible to say as much of the traction engines of 1871. No competent engineer who is not blinded by self-interest will attempt to prove that the traction engine is nearly as perfect in its way as the railway locomotive, nor yet that a degree of excellence has been reached which it is impossible to step beyond. Before the public can be satisfied, much better traction engines than any yet made must be built. We propose here to explain the reasons why the traction engine is still extremely imperfect, and to lay before our readers, as concisely as is consistent with the importance of our subject, the principles which should not for a moment be lost sight of by those who design steam engines intended to propel themselves and haul loads on our roads, and possibly on our fields.

It would be waste of time to examine here very closely the causes which have conduced to the comparative perfection of the railway locomotive. They are numerous, but one stands out more prominently than the rest. The railway locomotive has been built almost regardless of cost. We say "has been," because in the present day the greatest possible care is taken to keep down its price, both by the purchaser and the maker; but not so many years have elapsed since locomotives were built with regard to but one condition, to wit, that they should be the best it was possible to build; and this utter disregard of questions of first cost did a great deal, no doubt, if not all, to promote the progress to perfection of the machine. The best talent to design, the best materials on which to work, and the best tools with which to work, were all available, and properly so, because vast interests were at stake; but the case has been and is very different as regards the traction engine. Comparatively small sums have been spent in bringing these machines to such perfection as they possess. They have under all circumstances been made to sell. We do not use the words in an invidious sense, but with this meaning: railway companies who built their own locomotives built them to use, not to sell them. Manufacturers of locomotives, again, were formerly certain of getting remunerative prices. Not only was there a large demand, but there was practically no competition. The case has been totally different with the builders of traction engines. They have always built on speculation; they have had to do, not with wealthy companies, but with isolated individuals who have had to be educated into the belief that it was good for them to possess engines which would propel themselves on English roads and pastures. The construction of the traction engine fell into the hands of the agricultural engineer, and between agricultural engineers there is, and always has been, keen competition. It is not wonderful, under the circumstances, that the traction engine is still comparatively imperfect. The imperfection springs from two causes. In the first place, the builders in some cases do not know what is and what is not right in a traction engine; in other cases, they know very well, but they decline to adopt proper systems of construction, because they think these would of necessity involve an outlay which must be ruinous, because it would not be appreciated by the public. In this matter we believe that they are in a sense mistaken to some extent, but it is quite certain that if traction engines are not cheap they cannot be sold; and unless they can be made cheaply no sensible engineer will undertake their construction. Cheapness and efficiency are about as difficult to combine as oil and water. If as much money had been expended on the road locomotives as has been paid for experiments in traction on railways, it would be a far more useful and efficient machine than it is now, and would probably admit of being made with a profit at more moderate prices than now obtain. Whatever opinions others may hold on the subject, we are firmly convinced, by an experience extending over many years, that the locomotive is good because at first a very large sum was spent in bringing it to perfection; and secondly, because at one time large sums could be made in building such perfected engines; and that the traction engine is imperfect, because, in the first place, comparatively small sums have been spent in improving it; and because, in the second, manufacturers are not yet sure that a fair profit can be made by building engines of a superior type. Before leaving this part of

our subject we may add that on this latter point we believe them to be wrong. The demand for traction engines is in its infancy. Nothing is wanted to develop the trade to an enormous extent but the production of a thoroughly satisfactory engine. In pursuance of the purpose with which this article is written we shall now proceed to explain what it appears to us the traction engine of the future should be.

It would be very easy, with plenty of space at our disposal, to sit down and consider the traction engine under various heads. We might consider it as a steam generator, as a steam user, and as a vehicle ; but all the conditions are so closely united that it is very difficult within such limits as are at our disposal to consider these points as distinctly as is desirable. It is impossible, for example, to speak of the boiler without considering the relations which its form must bear to the whole machine considered as a vehicle. We shall endeavor, however, as far as possible, to group the points we propose to discuss, in order to avoid confusion.

The work to be done by a railway locomotive is essentially the same as that done by the traction engine. It consists in propelling itself, and a greater or lesser load, from place to place, by causing the rotation of certain supporting wheels called drivers. The great difference between the two machines is, that one works on iron rails, the other on roads or surfaces very various in quality, but invariably offering a much greater resistance to transit than a railway. It has been urged that the great difference consists in the fact that railways, being nearly level, while common roads are more or less inclined, the traction engine is called upon to exert extremely variable amounts of power. But this argument is not sound, as, compared with the whole rolling resistance of a rail; the inclines on most railways of recent construction are quite as severe as are the hills on ordinary roads, compared with the whole rolling friction. Whether on the railway or on the road the action of gravity on the inclines does far more to determine the load than the rolling friction. If this last amounts to 40 lbs. a ton on a good level common road, then will the resistance be just doubled by a hill rising 1 in 56. If the rolling resistance on a level railway be 10 lbs. per ton, then will the resistance be just doubled on an incline of 1 in 224. Inclines of 1 in 224 are quite as common on railways as inclines of 1 in 56 on common roads. Our readers may rest assured that the variation in the demands made on the powers of our railway locomotives are quite as great under ordinary circumstances as those found to exist in the demands made on the powers of our common-road locomotives.

No one will dispute that the locomotive practice of this country is thoroughly successful. Seeing, then, that a strict analogy exists between the work to be done by the two engines, one working on the rail, the other on the road, it is fair to assume that the traction engine builder may learn a great deal from railway practice. We have now to consider whether this assumption is or is not based on truth. The first point of difference between the railway locomotive and the traction engine is, that the latter is geared and the former is not. The crank shaft in the traction engine always makes several revolutions while the driving wheels make one. Now it can be shown that the use of gearing is attended with many and grave disadvantages ; so grave and so many, indeed, that it is worth while to consider at some length why gearing is used at all. A passenger locomotive of the ordinary construction with 6 ft. drivers cannot be depended upon to take four times its own weight up inclines of 1 in 30 at any speed. A moderately well designed traction engine with drivers of the same height will take four times its own weight up 1 in 20. When locomotives are intended to work steep inclines, they are made with small wheels, in order that the tractive force which they exert may be great. This expedient cannot be applied in traction engines, because, in the first place, the rolling resistance would be enormously increased, and because in the second the bite of the wheel on the road would be reduced. A railway engine weighing 25 tons, and taking a load of 100 tons behind it up 1 in 30, must exert a tractive force at the rails of $1250 + 9333 = 10{,}583$ lbs. If this engine had 4 ft. wheels, and a stroke of 2 ft., the distance passed over at each revolution of the drivers would be in round numbers 12 ft. 7 in., or 151 in. The two pistons would together pass over 96 in.

The mean pressure on 1 piston must therefore bear the same relation to the tractive force that 151 does to 96. It amounts, in other words, to 16,646 lbs. This divided by 100 lbs. for the pressure of steam on the sq. in., equivalent to, say, 130 lbs. in the boiler, gives us 166.46 sq. in. of piston. The pistons of our locomotive should therefore be $14\frac{1}{2}$ in. in diameter at least. In practice, such an engine would have cylinders 16 in. in diameter and 22 in. stroke, instead of 24 in.

Now a traction engine weighing 10 tons, and hauling 40 tons behind it up 1 in 30 on a good common road, must exert a tractive force of $2000 + 3735 = 5735$ lbs. The drivers of such an engine should not be less than 6 ft. high. Let us assume that they are a shade under, and that the circumference of the wheels is 18 ft.; let us further assume that the pistons are coupled directly on to the driving axle without the intervention of gearing, and that the stroke is 18 in. Then for each revolution of the drivers the pistons will pass over 6 ft. The mean pressure on one piston must, therefore, be three times the tractive force exerted at the road, or 17.205 lbs.; dividing this by 100 lbs. pressure as before, we get 172 as a quotient. This answers to a cylinder a little over $14\frac{3}{4}$ in. in diameter. In practice, such an engine would have a pair of cylinders $6\frac{1}{2}$ in. or 7 in. diameter and 10 in. stroke, geared down to the road wheels about 10 to 1. We have, as far as possible, put this comparison between a road locomotive and a railway engine in the clearest and simplest form, because we are aware that very confused notions exist, among many young engineers especially, as to the conditions under which engines haul loads, and the proportions which should be observed in designing them. We have thus considered the case of two engines doing the same relative duty; it now remains to be seen why gearing should be used in the one engine and abandoned in the other.

It is, of course, obvious that if gearing be dispensed with in traction engines, motion must be communicated to the driving wheels in one of two ways—either the driving axle must be cranked, or else pins must be fixed in the wheels for the connecting rod ends to lay hold of. It is very necessary in designing road steamers or traction engines that the driving axle should nearly coincide in position with a vertical line passing through the centre of gravity of the machine. In other words, the driving wheels should carry about 7-10ths of the whole weight, or even a little more. If a vertical boiler is used, with vertical cylinders over the cranked road-axle, as in the Thomson engine, it will be almost, if not quite, impossible to secure this object. The cranks must clear the boiler, and the latter will be thrown too far forward. Besides this, however, there is a great objection to the use of vertical cylinders in this way, the action of the steam causing the engine to jump up and down and roll about. This action is not—for reasons which require no explanation—manifested to the same extent when vertical cylinders are used with gearing. The distribution of weight might be managed pretty well with vertical boilers and cylinders if outside cranks were used. But then the cylinders would be thrown out very far from the boiler or any other basis of support, because of the great width of the road wheel rims. If the locomotive type of boiler be employed the cylinders must be put under the boiler, which is not in itself objectionable. Engines of small power have been made in this way with some success. There are, however, other objections to the direct system to be considered. In the first place, the cost of the crank-shaft must be very considerable, and its weight, and that of all the parts of the machine connected with it, must be very much augmented. The dead pull and push on each cylinder cover will be so excessive that very heavy fittings will be required to secure the cylinder in place. The use of these large cylinders without expansion would be extremely objectionable on the score of economy; but it would be impossible to have proper expansion with a plain slide valve, unless so large a lap was used that the engine would be constantly liable to "go blind;" and in climbing steep hills, or in positions of difficulty, the propelling force would vary very much throughout each stroke, a point to be of all things avoided, for reasons which we shall explain further on. It is not necessary, we think, to dwell on other objections, such as the weight and cost of the cylindes, the irregular action of the blast in the chimney. We have said enough to show that, except for high speed or pleasure

carriages, gearing must be used. But against gearing, in its turn, very serious objections may be urged. Its presence increases the cost and weight of the whole machine. It is peculiarly liable to fracture; the gearing is all but invariably the seat of every break-down that takes place. In order to keep it light it must be kept small, and thus engines may be found transmitting 40 or 50-horse power through cog-wheels 2 in. wide on the face and $1\frac{3}{4}$ in. pitch moving at a comparatively slow speed. Only the best possible materials and first-class workmanship can secure immunity under such conditions from the continual recurrence of accidents, and so we find that steel or malleable cast iron is being used in the gearing of all really good traction engines. But these materials cost a great deal of money, and it will be found that a point is soon reached beyond which the balance of advantage might lie with the direct system ; if only the difficulty concerning the want of equality of action could be got over. This might be disposed of by the multiplication of cylinders, and there is little room to doubt that *in the abstract* a better traction engine might be constructed with 4 cylinders each $10\frac{1}{2}$ in. in diameter and 18 in. stroke, driving the crank shaft direct, than one with two $6\frac{1}{2}$ in. cylinders, 10 in. stroke, and a lot of gearing ; but the cost of such an engine would be much more considerable than that of the geared engine, and its weight would, on the whole, be perhaps greater. Whatever theoretical view may be taken of this subject, it is certain that in practice, and under the ordinary conditions of trade, gearing of some kind must be adopted in traction engines.

The gearing used in traction engines may be classed under three heads: (1) spur gear; (2) chain gear; (3) chain and spur gear. In very light pleasure carriages gut bands have been employed, and in some of the American steam-propelled street cars—called " dummy locomotives" —leather belts have been used to communicate motion from the crank-shaft to the road wheels; but it is unnecessary to do more than mention expedients only applicable in very exceptional cases. We shall, therefore, confine ourselves to the consideration of those systems of construction which are habitually employed, or have been resorted to with some success.

Before deciding on the arrangement that shall be adopted in communicating motion from the crank shaft to the driving wheels two things must be taken into consideration—firstly, the relative positions of the two shafts, and, secondly, the first cost to be incurred. The relative angular velocities of the shafts have very little to do with the matter, because, within the limits of velocity of rotation which obtain in traction engines, either chains or gearing, or both, can be employed. As regards the first point, it may be laid down as an axiom that the use of " idle " wheels is to be deprecated; as regards the second, it is certain that a properly made chain costs more than the spur gear to which it is the equivalent. Messrs. J. Fowler and Co., of Leeds, use spur gearing in which an " idle " wheel forms an important part in their ploughing engines. But it must be remembered that these are self-propelling engines, not intended to haul loads. Their propulsion is altogether a secondary consideration. Their principal work is done in causing the rotation of the winding drums below the boiler; and the position of this drum is such that of necessity the driving wheels must be kept well back to clear the rope, while the crank-shaft must be kept well forward to suit the position of the vertical shaft at the front corner of the fire-box. A glance at the engraving published in " The Engineer " for July 21st, page 36, will make our meaning perfectly clear.

In designing a traction engine it will not do to leave everything open; some fixed point of departure must be settled upon. This point should be the tractive force which it is intended the engine shall develop. To go no further back, it has been proved at Wolverhampton that an engine with elastic tired wheels will possess sufficient adhesion to haul a gross load including the engine, of five times the load on the drivers, up 1 in 18 on a good road. Let us take it for granted, however, that the maximum load to be moved is five times that on the drivers up 1 in 20. Let us also assume that our engine shall weigh 10 tons, of which 7 are carried by the drivers. The total load will then be 35 tons, and the net load 25 tons. Let us further take the resistance due to what is called road friction to be 40 lbs. per ton, then it is clear that the tractive force exerted at the surface of the road must be 1400 lbs. to overcome road resist-

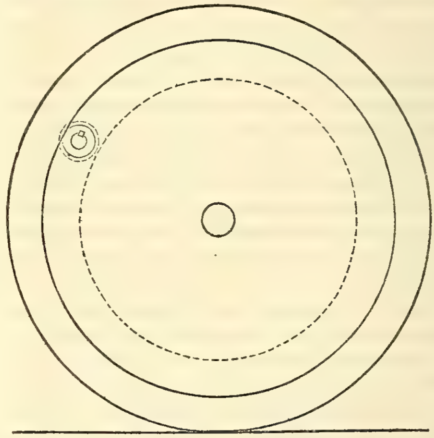
ance, and 3,920 lbs. to overcome the resistance due to the incline of 1 in 20. The total tractive force to be exerted must therefore be 5,320 lbs. Once in possession of these figures we are in a position to settle the diameter of our cylinders, their stroke, and the ratio of gearing we shall adopt with any given boiler pressure. We are indebted to Lieut. Crompton for the following formula embracing the solution of the entire problem thus stated, and making an allowance of about 30 per cent. for engine friction, including of course that of the gearing:—

Let A be the area of one cylinder in inches, let p be the average pressure throughout the stroke, S the length of stroke in inches, R the ratio of gearing, C the circumference of a driving wheel in inches, T the tractive force in pounds. Then $T = \frac{8\,A\,p\,S\,R}{3\,C}$.

Further on we shall show reasons for abandoning the existing system of very small cylinders and very high pressures. Let us assume that we shall have in our 10 ton engine two 8 in. cylinders, with a stroke of 10 in.; that the average presure in the cylinders is 75 lbs.; that the velocity ratio of the gearing is 12 to 1, and that the driving wheels have a circumference of 226 in., corresponding within a minute fraction to a diameter of 6 ft. A piston 8 in. in diameter has an area of a little over 50 sq. in. Substituting these figures in the formula, we have

$$\frac{8\times50\times75\times10\times12}{3\times226} = 5310 \text{ lbs., omitting fractions.}$$

An 8-in. piston is a shade over 50 in. in area, and, taking this into consideration, it will be found that the result given by the preceding calculation comes quite close enough for all practical purposes to the required conditions. A pressure of 100 lbs. in the boiler, we may add, should give more than the average pressure required in the cylinder if the cut-off took place at half stroke. It may be as well, before proceeding further, to state the velocity of the engine for a speed of $2\frac{1}{2}$ miles an hour—quite enough, perhaps, for the load on an incline so steep as 1 in 20. A driving wheel 6 ft. high will revolve 280.3 times in passing over a mile. As our driving wheel is a shade under 6 ft. high, we shall take the revolutions in round numbers. Therefore, in traversing 2.5 miles it will make 700 revolutions. This divided by 60, gives us 11.66 as a quotient, and this multiplied by 12, the ratio of gearing, gives us very nearly 140 revolutions per minute of the crank shaft. From this it will be seen that with a speed little in excess of that adopted very generally in portable engines, we can obtain with an engine such as we have described, a fair speed on the road with a very heavy load. And it must be remembered that Lieutenant Crompton's formula is based, not on theory, but on the results of a great many experiments made with Thomson's engines, and is therefore reliable, as any of our readers will find by checking it with the ordinary formula, which assumes the shape:—as space passed over by driving wheels in one revolution is to space passed over by pistons in the same time, so will the tractive force be to the force exerted on the pistons.



The engine which we have sketched out in its three important properties, viz.: height of driving wheel, ratio of gearing, and cylinder capacity, differs in two important respects from what we may call the fashionable engine of the day—that is to say Thomson's. There we have small cylinders, an exceptionally high pressure of steam, and a velocity of crank-shaft rotation without any parallel in engines intended to do heavy and continuous work. In our engine, on the contrary, we have large cylinder capacity, a moderate, but yet not slow speed of piston—about 56 revolutions per minute per mile per hour. As regards the advantages conferred by using a large instead of a small cylinder, we shall have something more to say when we come to consider the question of boil-

er pressure. The advantages of a moderate speed of rotation in the crank shaft should by this time be well understood by all engineers; by none are they more fully appreciated than by those who have had most to do with high-speed engines. This is a point, however, on which we must not stop to dwell. We hold that it may safely be laid down that an engine with two cylinders, running at 140 revolutions or thereabouts when the load is moving at 2½ miles an hour, will be competent to get out of any difficulties in which it is likely to be placed, and will prove itself thoroughly efficient and economical.

If our opinions express, as we think they do, the truth, it follows that gearing in ratio of 12 to 1 will suffice—if it be not the best possible ratio for *most* traction engines. But our readers must not fall into the error of supposing that we assert it to be the best possible ratio for *all* traction engines. If the track to be traversed is very bad indeed, like some of the so-called roads in Scotland, which in winter resemble the bed of a torrent more than anything else, or if inclines of more than 1 in 18 are likely to be met with, then it will be well to increase the ratio to as much as 14 or 15 to 1, but beyond this it is seldom necessary to go. On the other hand, if the track is exceptionally level and good, as, for example, in some districts in France, where inclines of 1 in 30 are not exceeded, a less ratio, say 7 or 8 to 1, may be adopted. The designer must suit his engine to the circumstances under which it is to be employed. Under the conditions which usually obtain, a ratio of 12 to 1 will, we think, be found most convenient.

We have now to consider whether, in using such gear, we shall do it at once, or do it at twice; in other words, shall we, or shall we not dispense with a countershaft? Now the saving to be effected by dispensing with the countershaft is enormous. We at once get rid of something not much short of 5 cwt. of extra weight in heavy engines, and from 1 cwt. to 3 cwt. in light engines; we also get rid of another seat of breakage; we save in the first cost of the machine, and in the consumption of oil and brasses, and, finally, we dispose of a shaft which is continually obtruding itself in the way of the designer on paper, and of the driver on the foot-plate—at least as regards engines of the Fowler, and Aveling, and Porter type. If two speeds, fast and slow, are adopted, however, the countershaft is convenient. Shall we, or shall we not, have 2 speeds, say, 14 slow and 8 fast, or any other ratio? In our opinion, the balance of advantage is against two speeds, because it introduces a second set of wheels, unless they are adopted in a way to which we shall refer presently. If sufficiently large cylinders are used, all the advantages of the slow speed can be had without its disadvantages. Suppose the engine makes 56 revolutions per mile per minute, then at 5 miles an hour we have 280 revolutions, and steam cut off at a quarter stroke; at 2 miles an hour we can use it nearly full stroke. The high velocity of the engine is not at all so objectionable when expanding as when working steam full stroke, but most of the small cylinder engines work nearly full stroke at 300 revolutions in slow gear. Let us take it for granted that our 10-ton engine, the proportions of which we have so far reasoned out, is to be of either of two types, that is to say, either single-speeded 12 to 1, or double-speeded 12 to 1, and some quicker speed, an arrangement very suitable for a road moderately level for the most part, but including 2 or 3 inclines of 18 or 20 to 1. We cannot do better at this stage, having got so far, than indicate the general arrangement of engine we would be disposed to adopt, and give our reasons for adopting it afterwards. As regards the proportions of the cylinders, gearing, and driving wheels, we have already spoken. We have now to consider the position of the relative parts.

The boiler in our engine would be of the locomotive type. As to its proportions we shall speak by and by. The cylinders placed in the smoke-box somewhat, but not quite as in a locomotive; they are to be kept as high as possible. The driving-wheel axle is to be placed under about the middle of the boiler barrel. The engine will run fire-box first. A glance at the engraving of Burrell's engine, in our impression for July 21st, will explain our meaning. The slide bars, etc., must be carried over the shaft, inclined cylinders, as in goods locomotives, being strictly admissible. Two wrought-iron side frames extending from the smoke-box to the fire-box will be em-

ployed to carry the road axle and the crank shaft. The crank shaft will be placed well up toward the fire-box. If the engine is single-speeded each road wheel will carry an ordinary geared ring, as in the Thomson engine, 5 ft. diameter on the pitch line. The crank shaft will carry two pinions, one at each end, either or both of which can be thrown out of gear. These pinions must be 5 in. in diameter on the pitch line, and will have 8 teeth 2.45 in. pitch and about 3.25 in. wide. If made of steel and properly fitted these pinions will be strong enough to transmit the whole power of the engine. As the crank shaft, also of steel, should not be less than $3\frac{1}{4}$ in. diameter, the pinions must be made with a heavy flange or shroud, to afford strength and take the fast feather in the crank shaft. We shall then have gearing speeded 12 to 1, and we can fix the driving shaft on which the wheels will revolve, and which may be bent down out of the way of the slide bars. If, however, we elect to have two speeds, then the cogged rings must drive the main road wheel axle, which will then revolve. The road wheels may have motion imparted to them from the cogged rings, either by a pin, as in ordinary engines, or by a friction strap. The slow speed will be got as before. The fast speed will be got by making the cogged ring at one side with external instead of internal teeth, and proportionately reducing its diameter. The pinion may also be made a little larger. The annexed diagram will illustrate our meaning. The full circles show the slow speed at the near side of the engine; the dotted circles show the fast speed at the far side, the large ring shows the road wheel. The arrangement is simple and mechanical in all respects but one, viz., the small diameter of the pinion; but with proper workmanship and material this evil is not nearly so great as it appears at first sight, and cannot possibly, we think, equal the objections which obtain against the use of a countershaft. Both the pinion and the ring are shrouded, which much augments their strength, and it must not be forgotten that a pinion rolling inside a circle works to far more advantage than one working outside. Another objection is that only one pinion can drive at a time, but the internal ring can be made a little larger in diameter than 5 ft., and the pitch proportionately augmented.

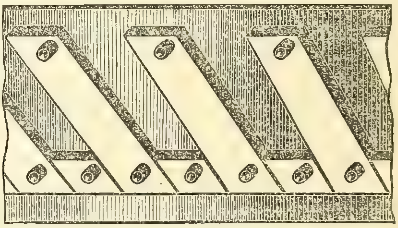
So far we have only spoken of spur gearing in its simplest form, and we may add that we are by no means certain that spur gear is the best that can be used; on the contrary, our predilections are all toward the use of chain gear.

One great point in favor of chain gear is the facility which it affords the designer for placing his engine on springs. The crank, or countershaft, or both when both are used, must be fixed in position with relation to the boiler and the framing or saddles. They cannot be fixed in relation to the driving wheels unless resort is had to very complex expedients, such as those adopted years ago by James, and more recently by Barrans. If it were possible for the crank shaft or countershaft, with its or their bearings to move up and down through the range of the springs in arcs concentric with the toothed wheels fixed on the driving shaft, all would be well, but this, from the nature of things, is impossible consistently with simplicity. Even if it could be done, the action of the springs would be so far tramelled that they would be deprived of some of their utility. If the crank or countershaft move up and down in vertical lines it is obvious that the depth to which the teeth of the gearing interlocks must vary continually; and this is not all, the presence of springs implies a certain liberty for longitudinal motion in the shaft in the direction of the axis of the boiler—if that be horizontal—which would be fatal to the permanence of the gear. If we adopt a chain the whole difficulty is got rid of. If the axis of the chain pinion and that of the chain wheel are nearly on the same horizontal line, the latter may play up and down through some inches without effecting the action of the chain, and the slight amount of slack invariably present in the latter permits a liberty of longitudinal motion in the driving axle, otherwise unattainable. When the chain pinion is carried high over the driving axle, as in Aveling and Porter's engine nearly all this advantage is lost. It may be laid down as a rule that springs cannot be combined with chain gear if the angle made by the line of centres of the chain pinion and the chain wheel exceeds 45 deg. At a less angle than this, Burrel used india-rubber springs over his driving axle with con-

siderable effect. The action of the spring is, however, not at right angles to the road, but at right angles to the line of centres. To derive full benefit from a chain it should be put to work with the line of centres as nearly as possible horizontal. It will be urged, perhaps, that springs are not needed in traction engines; this is a complete mistake. In the earlier days of the railway locomotive springs were not used. A locomotive without them in the present day would be looked upon as a mechanical absurdity. It is quite true that traction engines for slow speeds get on without them, but they are absolutely essential at speeds above 4 miles an hour. They not only assist in saving the machinery from many rude strains and shocks, but they increase adhesion, and reduce the resistance of the engine itself regarded as a vehicle. Strange as it may seem, their presence is directly conducive to economy of fuel. On rough roads, the fires in engines without springs get wonderfully knocked about, and the small coal is sifted through the bars in a way which must be seen to be believed. A case came under our own knowledge in which the consumption of fuel was increased over 15 per cent. by slightly increasing the width between bars previously placed so closely together that some trouble was experienced in maintaining a draught. Any one who will examine the contents of the ashpan of a traction engine with springs, and of one without, after running a couple of miles on a hard road at a fair pace, will be able to form an opinion on this subject for himself. Of course, if Thomson's, or some other elastic wheel be used, the necessity for springs is nearly removed; but no one who has experienced the beautifully easy floating motion experienced when the Thomson tire is combined with even stiff axle springs, will like to discard the latter without very good cause.

The second fact in favor of chain gear is that when it is properly made it is much less likely to break down under a heavy strain than spur gear. In the best constructed spur gear not more than 2 teeth in each wheel can be at work at the same time, and to all intents and purposes the whole force of the engine must be transmitted, as a rule, through a single tooth at a time. When a chain is used the case is different, as it is in wrapping contact with the wheels. The strain to which it is subjected is diffused over a number of teeth, just as in a belt the strain is diffused over most of the surface of each pulley instead of being concentrated on one or two points. Of course much of this advantage, especially as regards the chain pinion, may be lost if the pitch of the chain is unequal, and the teeth with which it gears are badly shaped; but if the entire gear is well made to begin with, a natural adjustment takes place as the parts wear, and the breaking out of a tooth is, under these circumstances, almost unheard of. The chains may break, or the chain pinion or chain wheel may be split, but the gear will not strip.

The great objection to the use of the chain is its tendency to lengthen when in use. There are three different varieties of chain employed by builders of traction engines, which we illustrate in the accompanying diagrams, but the general principle of construction is the same in all—in every case the chain resembles that of a watch. The first kind of chain consists

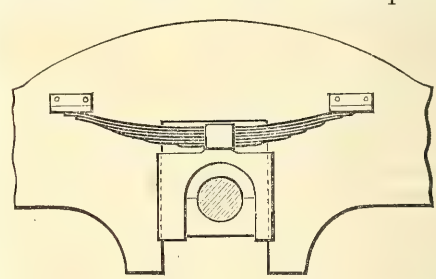


of side plates and cross pins only. No worse form of chain can be used, because the bearing surface of each pin is so small that it is certain to wear out rapidly. It is obvious that this must be the case, because the wearing surface of the pin—that is to say, that portion of it which comes into contact with the teeth of the chain wheels — can be no longer than the space between the inner links. Increased surface could only be got under the conditions either by making the pins inconveniently thick or inconveniently long. For various reasons on which we have not space to dwell, the chains should always be made as narrow as possible. A far better form of chain is that shown in Fig. 2. Here every second link is a solid block, to begin with, near each end of which a hole is drilled for the

pin. This is the form of chain used by Messrs. Aveling and Porter. The pins do not come in contact with the teeth, the ends of the blocks taking their place. With the same total width of chain, the length of bearing surface becomes the same as that of the pin in Fig. 1, increased by the thickness of the two inner links. It has hardly yet been settled whether the pins should be fast in the blocks and loose in the link, or *vice versâ*. We prefer to fix them in the side links by riveting them up tightly against the shoulder. A third form of chain, lighter and cheaper than the last, is shown in Fig. 3. Here straps welded up take the place of the blocks. Such chains work very well indeed after they have stretched and come to a bearing, but they are hardly so good as the Aveling chain. Within the limits of such a series of papers as these it would be impossible to treat properly of the correct form of tooth to be used with chains. Our readers will find the subject deat with in Rankine's "Machinery and Millwork," p. 190. Under no circumstances should more than five teeth be used in the chain pinion.

In all cases the chain should be made as light as is consistent, not with strength, but with sufficient bearing surface. That being present, the chain is certain to be strong enough for any strain that can be thrown on it. There are three ways of using a chain. It may be applied to drive a counter shaftfrom the crank shaft, which countershaft then drives the road wheel by spur gear, or it may be employed to drive the road wheels direct from the crank shaft, or direct from the countershaft, which is then driven by gearing. The first arrangement is extremely defective; in it we have a light chain running at a high speed, which is wrong, and we sacrifice besides all the benefits to be had from the use of chains as enabling us to use springs, unless, indeed, some such arrangement as that exhibited by Tuxford at Wolverhampton this year is used. In all cases, however, it appears to be best to use a good strong chain running at a slow speed to drive the road wheels direct from the countershaft. It may also be laid down that when a chain is used it must be accompanied by a countershaft if the velocity ratio of the gearing is to much exceed six to one. The pitch of the chain cannot be kept as fine as the pitch of spur gear. A 5-toothed pinion cannot, in an engine intended to do hard work, be much less than 8 in. in diameter, which, with a 5 ft. chain wheel, would give a velocity ratio of 7.5 to 1 only. The following is a very good combination:—With 6 ft. drivers the chain wheel is 4 ft. in diameter, the chain pinion on the countershaft is 12 in., so that the countershaft makes 4 revolutions for 1 of the road wheels. In fast gear, the crank shaft makes 2 revolutions for 1 of the countershaft; in slow gear it makes $3\frac{1}{4}$. The ratio of gearing is, in the first instance, 8 to 1; in the second, it is 13 to 1.

We have stated that one of the principal objections to the use of chain gear is that the chain gear becomes slack, and requires to be tightened up; the slackness results from wear in the pins and links, and if it were not compensated for by wear in the teeth of the pinion and chain wheel the pitches of the two would not coincide; as it is, the pinion, having much less surface, wears out a good deal faster than the chain wheel, and it is not a bad practice to suppress every second tooth in the chain wheel to insure more equable



wear. A good chain, laterally stiff, will run very well, even if it is very slack; but when the pins have worn so much that its lateral stiffness is much diminished, it is liable to come off when run pretty fast, therefore some expedient for taking up wear is essential. There are numbers of these in existence; the best plan consists in moving the axles of the chain wheel—that is, the driving axle—and that of the chain pinion—the countershaft—further apart. The usual plan is to move the countershaft as in the Aveling engine. This is effected by taking liners from above the brasses and putting them below. When a single stud is used instead of a countershaft on which the chain pinion turns, a nearly similar arrangement is

adopted. The plan works very well, but we have reason to think that it would be better to move the road wheel axle a little further back. The range of motion required is very small, shifting one of the shafts through half an inch will take up the whole chain 1 in., because both sides of the chain are tightened at the same time. A total range of 1 in. in the distance between the axles will generally suffice. By the time that is used up, the chain will have augmented sufficiently in pitch to permit the chain pinion to be changed for one a little larger in the body; or the range of motion may be increased so far, that when it is all used up a link may be taken out of the chain and the bearings shifted back to their original position. There are several ways in which the shifting of the axle may be effected. We illustrate one in the accompanying diagram. Here it will be seen that the main axle runs in brasses—or, more strictly, cast-iron blocks lined with brass—which play up and down in angle iron horn-plates on the side frames. These cast-iron blocks have more metal at one side than the other. To begin with, the thin side is put to the front. After the chain has worn sufficiently, the engine is jacked-up and the blocks are taken out and turned the other way round, by which means the wheels are shifted back half an inch. When the wheels have to be shifted again, new cast-iron blocks are used, with the brasses disposed still more to one side. As the spring always finds a bearing over the axle centre the change does not affect its action in any way. The arrangement is cheap and simple, and very efficient. There are many other devices for securing the same end, on which we need not stop to dwell. We have now briefly discussed the principal features of the traction engine, considered as an engine only.

The best traction engine which it is possible to build is useless without a good boiler to supply it with steam. This fact should be sufficiently obvious; and yet an examination of the history of steam propulsion on common roads will show that it has been systematically neglected. The first engine that ever ran on a road was invented by Cugnot, and tried in the year 1770. It could only run for a about a quarter of an hour continuously, and had then to stand for about the same space of time to get up steam again. This was a bad beginning, and for very many years after Cugnot's time the want of boiler power retarded the introduction of steam on common roads. If any of our readers will but glance at the engravings published in any treatise on the steam engine showing road locomotives, he cannot fail to be struck with the obvious inadequacy of the means provided to secure the required end. We have stage coaches propelled by large cylinders, the boiler occupying no more space than the "boot"; we have omnibuses just as well provided with cylinders, the boilers consisting of a few tubes, and a fire-box which would hold about a hatful of coal. It is not a matter for surprise that such machines were failures. Even in the present day boilers far too small for their work, or improperly designed, are adopted without hesitation by engineers who ought to know better. This is not and has not been done without reason, and the reason is easily found. The boiler is an extremely inconvenient feature in road steamers, traction engines, or steam omnibuses. If of proper dimensions it takes up a great deal of room, and is very heavy. Therefore persistent attempts have been made to reduce its weight and dimensions, and the notion has obtained that by increasing the working pressure the dimensions of the boiler might be reduced. We have heard it urged that by doubling the pressure a boiler might be halved in size, still retaining the same power. If this were true, then a boiler about the size of a quart pot, heated by a spirit lamp, and worked at 1,000 lbs. on the sq. in., would suffice for all ordinary purposes. The great lesson has yet to be learned, we fear, that as in locomotives and marine engines, so in traction engines, ample boiler power must be provided before any satisfactory result can be obtained.

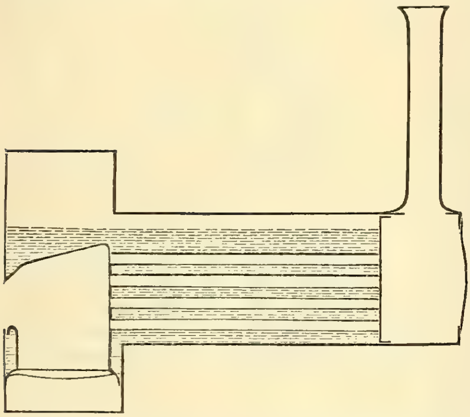
No locomotive superintendent ever troubles his head now as to the type of boiler he will use. No designer of traction engines sets to work with bow, pencil and square, without inward misgivings as to the relative merits of horizontal and vertical boilers. Whichever he selects, he will, he fears, be sorry he had not chosen the other. For ourselves, we have no doubts on the matter; the experience of locomotive superintendents, extending over a period of nearly forty years, has demon-

strated that no type of boiler is so suitable for the purposes of locomotion as that ordinarily used on our railways. What is true on the rail is true on the road. We give an unqualified preference to the locomotive type of boiler for traction engines. There is not a single argument that can be urged against it possessing the smallest weight but one. When descending steep hills the top of the fire-box may be left bare of water. The evil is purely imaginary. In our own experience we have never so much as melted out a lead plug from this cause. Messrs. Aveling and Porter, who use only the locomotive type of boiler, never experience any trouble from this source. Even Messrs. Fowler and Co. of Leeds, whose ploughing engines have often to stand on steep inclines for hours together, adhere to the horizonal type. As regards the subject with which we are dealing, the traction engine proper, not the self-propelling ploughing engine, it is evident that at the time risk is run of burning the top of the fire-box when running down hill, little or no steam is needed. If the hill is a long one it suffices to put a little fresh coal, equally distributed, over the grate, and to open the fire-door; the box cannot then be overheated. On short hills opening the fire-door will suffice; but it does not follow from all this that we should use in the traction engine a boiler *proportioned* exactly like that of the locomotive; on the contrary, as the conditions under which a traction engine works are somewhat different from those under which a locomotive performs its duties, some alterations must be made in the boiler; but these alterations are simply changes in detail, not in principle.

In the first place, as the engine must be prepared to work on inclines unknown in railway practice, means must be adopted to guard against the fire-box crown being left bare when descending them. It is therefore expedient to carry a good depth of water over the fire-box on a level. This can be effected either by working the boiler very full of water, or by keeping the fire-box very low. If we adopt the first plan we run the risk of priming, if the latter we reduce the space available for the insertion of tubes. A combination of the two plans appears likely to give the best result. The back part cf the internal fire-box should be lowered, and the external fire-box should be kept high with regard to the barrel, or else a steam dome should be fitted to the latter. No locomotives work steam so dry as those with domes, and if it is found worth while to admit them on our railways, they will be found still more useful on common roads. On our railways nothing but very pure and good water is ever used. The traction engine has to make steam of any water that comes to hand. The use of a high, narrow dome is the best possible means of preventing water entering the cylinders. It may be dispensed with, however, if its equivalent in the shape of a raised fire-box shell is adopted. The accompanying diagram will illustrate our meaning better than a long description. The barrel here is kept low on purpose to allow plenty of tubes to be put in, and it is worked nearly full of water. This secures a good depth over the top of the fire-box, while ample steam space is supplied by the raised crown of the outer shell ; under such circumstances no steam dome is needed. However, for ourselves we prefer a boiler flush from end to end, as being simpler and cheaper to make, with a tall, narrow dome near the chimney. The principal point to secure is that the fire-box crown shall have plenty of water over it when the engine stands on a level. If this is the case there is no danger of burning the fire-box crown going down hill, provided the barrel of the boiler be not too long, and as this mistake is never committed by builders of traction engines we need not further refer to it.

We have now to consider what the dimensions of the boiler should be for a given power, and that this is after all possibly the most important point that can be discussed. The moment we come to consider it we discover why it is that the vertical boiler cannot compete with the horizontal type. The grand defect of the former is that, under the given conditions, as much heating surface cannot be got into it as into the locomotive boiler. There is, indeed, one vertical boiler which competes successfully with the horizontal on this basis, supplying more heating surface, of the best quality too, in a given space, than any other with which we are acquainted ; but inasmuch as this boiler has not yet been used with traction engines, it is unnecessary to say more about it than that in some respects it resembles

the boilers used by Messrs. Shand and Mason in their latest designs. Those who have read these articles attentively will remember that we proposed to adopt in our theoretical 10 ton engine cylinders 8 in. in diameter by 10 in. stroke, the diameter being considerably greater in proportion to the commercial power than that used by any maker at present. We shall assume as before that 140 revolutions are made per minute when the engine is travelling at $2\frac{1}{2}$ miles per hour, and that the average pressure in the cylinder is 75 lbs., or, providing for back pressure, let us say, to be on the safe side, 80 lbs. per sq. in. At 140 revolutions the engine will use 560 cylinders full of steam per minute. The contents of each cylinder, including clearance and ports, may be taken as $\frac{1}{3}$ of a



cubic foot. Therefore the whole consumption per minute will be a little less than 186 cubic ft. per minute, or per hour 11,220 ft. The volume of steam at a total pressure of 80+15=95 lbs., water being 1, is 280.5 ; consequently, to supply 11,220 cubic ft. of steam per hour, we must evaporate 40 cubic ft. of water. Now a good locomotive boiler properly fired, and with an adequate draught, will evaporate about 1 cubic ft. of water per hour for every 5 ft. of heating surface, consequently our boiler must have at least 200 ft. of surface; less than this can be made to do, but it cannot be made to do with economy. A striking instance of the defects of the vertical boiler is supplied by the case of the Chenab, shown at Wolverhampton. This engine had but 109 sq. ft. of surface to supply two cylinders. Aveling and Porter's 6 horse engine had 109 sq. ft. of surface to supply 1 cylinder, somewhat less in diameter, the piston speed being nearly identical. The boiler of the Chenab was made still worse by feruling up the tubes until the draught was reduced. But it appears from this it is obvious either that Messrs. Aveling and Porter give a great deal too much surface, or the Chenab had far too little ; the results of the tests, which have already been fully reported in our columns, justified Messrs. Aveling and Porter's practice. If builders of traction engines would lay it down as an invariable rule, that 5 sq. ft. of heating surface must be used to evaporate one cubic ft. of water, they would never have to complain of want of steam, provided the boiler is otherwise right.

Only one other point connected with boilers remains to be discussed here, viz., the pressure to be carried. This should in traction engines never exceed 120 lbs.—100 lbs. is to be preferred. Higher pressures are only adopted because the cylinders used are too small. The extra weight introduced into a pair of cylinders by increasing their diameter from 7 in. to 8 in. is nothing compared to the weight and cost incurred in making a boiler fit to carry 140 lbs. instead of 100 lbs. We shall return to this branch of the subject.

It is not more certain that the best arrangement of machinery which put together constitutes a traction *engine* is useless without a good boiler, than that it is useless without good wheels. We have dealt with the engine, the gearing, and the boiler. We have now to treat of the wheels, a subject which has attracted a great deal of attention from mechanical engineers during the last couple of years.

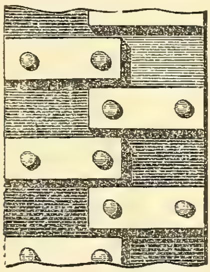
The first wheels used with traction engines appear to have been made of wood, of considerable width, and shod with strips of iron. They closely resembled ordinary gun-carriage wheels. Then came wheels with wrought-iron spokes and cast-iron rims. Next, wheels all of wrought iron, except the hubs, were tried. The latest improvement is the Thomson wheel with india-rubber tires. In dealing with this branch of our subject we shall speak only of what may be termed commercial wheels, that is to say, wheels which have been, or are, used with success in daily practice. It is quite beyond the scope of this article to speak of the hundreds of devices which have been proposed from time to

time to secure adhesion and elasticity. Passing over these, we may state that the wooden wheel had many advantages which long made it a favorite with a few builders of traction engines. In the first place, wooden wheels possessed no small elasticity. Made, as they were, without continuous tires, they flattened on the road, slightly it is true but still with benefit, by the springing of the timber felloes, which were shallow in proportion to their breadth. Each spoke, too, was in a sense a spring, or at least a very efficient deadener of vibration. The wooden wheel, again, was silent. It did not ring as it crossed gravel or broken stones, and this was a much more important point than is generally believed. As regards adhesion, if the iron tire straps were properly fitted with projecting rivet heads, it was quite equal to, if not better than, any iron wheel. The wooden wheel was, however, open to serious objections. It was expensive if proper materials and modes of construction were adopted; and it was very difficult to make it strong enough to carry the increased loads gradually adopted by engineers. The material, too, was peculiarly susceptible to climatic influences; for these reasons no wooden wheels are now used by makers of traction engines, at least as drivers, although they are retained with advantage in certain cases, by Messrs. Aveling & Porter, and one or two other firms, for leading wheels, for which, as the loads are light, the material is well suited.

Wheels made wholly of wrought iron are little used, and then so far as we have seen only in small engines, such as Aveling & Porter's "Steam Sapper." That such wheels are, when well made, very good is certain; but, unless they are used in conjunction with springs, they are always liable to become rickety, especially when worked on rough or paved roads. The rivets elongate and become loose, and ultimately the wheel goes to bits. To all intents and purposes only two varieties of wheels are generally used in the best modern practice. The most common has a heavy cast-iron rim, a cast-iron hub, and wrought-iron spokes, put in at some angle, or so bent that they provide a certain amount of elasticity. This is essential, not so much for the sake of the engine when running, because the tire being cast round the spokes, would, when contracting in cooling, certainly burst if the spokes were absolutely rigid. The great difficulty to be overcome lies in securing an intimate union between the wrought and cast iron. The ordinary plan is to fix the spokes in the floor of the foundry in position, and to cast the rim round them. When this has set and cooled down to about a red heat the boss or hub is cast. If the casting of the latter is delayed till the outer ring is quite cold it will be liable, if of large size, to draw away from the spokes fixed in the rigid tire. The great point is so to proportion the temperatures of the two portions of the wheel that the contraction may be equal throughout the whole; and this is very successfully accomplished in the present day, although the contrary was the fact a few years since. Three or four methods of making the cast iron unite with the wrought, or, at least, of permanently securing the one to the other, have been tried. The simplest is to split the ends of the spoke and open them out slightly for an inch or two; round spokes are notched like a lewis. Some makers punch one or two holes in each end of the spoke, which the fluid metal fills, forming a permanent pin or cottar. But none of these plans will alone suffice to prevent the spokes from becoming loose in time. To avoid this an intimate union—a partial welding or soldering, so to speak—must be established between the two metals. This can only be effected by running much more iron through the mould than is wanted, and so "burning" the spokes in, or else by coating the ends of the spokes with some flux which will answer the purpose of establishing a union, on the same principle that a tinsmith uses resin, or a gasfitter muriate of ammonia. There are various nostrums in favor for effecting this end. One is gas-tar, into which the ends of the spokes, well cleaned, are dipped before putting them in the mould. We have ourselves tried this, with very indifferent results, although others have been more successful. The best plan is to tin the end of the spoke. We cannot call to mind a single instance in which a tinned spoke became loose, if proper care was used to feed the casting with rods during the first twenty minutes or so after the metal was poured.

In whatever way a rigid wheel is made, it is essential to its success that its sur-

face must be roughened. A smooth wrought-iron tire possesses very litte bite to begin with, and after it has worn itself bright by slipping, it has practically no adhesion. A cast-iron tire is still worse ; it is, therefore, the custom either to cast ridges across the tire or to fit it with strips of wrought iron about 4 in. wide and $\frac{3}{4}$ in. thick, disposed spirally across the rim, with vacant spaces between the strips. The spiral arrangement is intended to prevent the jolting which would otherwise take place as the vacant spaces and cross bars alternately came to the ground. In other respects the arrangement is prejudicial. The best possible way to make a rigid wheel hold well is shown in the annexed diagram, but the system is rather costly. We have here a nearly continuous



rib round the centre of the breadth of the wheel, but the moment any abrasion of the road from slipping occurs the bars get a good hold. Each strip is of soft wrought iron, fixed by two steel rivets, the snap heads of which—on the outside—are well developed, and conical instead of hemispherical. From such a wheel, about 7 ft. in diameter and 18 in. broad, the maximum adhesion of which a rigid wheel is capable may be had. The Thomson wheel, the second variety to which we have alluded, has so frequently been illustrated in these pages, that we need not again consider its peculiarities here ; they must be familiar to our readers.

Having thus generally indicated the principles observed in the construction of traction engine wheels, we have next to consider the nature of the laws on which their adhesion, and, therefore, their relative efficiency depends. The subject has hardly yet been dealt with as it ought, and one or two letters which have appeared in "The Engineer" go to show that the subject is very imperfectly und rstood.

It is commonly assumed that the adhesion of the wheel of a traction engine is simply a function of static friction, and the well-known laws of friction not being found to apply, all manner of hypotheses are adopted to explain the apparent paradox. To put this in a plainer light, let us define the principal law of friction implicated. It is that the resistance—which in this case is synonymous with adhesion—is totally independent of the extent of the surfaces in contact, and directly proportional to the forces holding these surfaces together. Now it is perfectly well known that an elastic or Thomson tire possesses more adhesion than a rigid tire in the proportion of about 5 to 3 on good roads, and there are no means of explaining this fact except that the elastic tire extends the surface of contact. But it is objected that nothing is to be had from this extension, because adhesion is independent of surface; and therefore we have been furnished with more than one ingenious theory to explain what really is extremly simple, and should be quite obvious. It is quite true that friction is independent of surface, so long as the surfaces remain intact, but it ceases to be true the moment abrasion takes place. To illustrate our meaning, let us suppose a bar of lead to be cast 1 in. wide, 10 in long, and $\frac{1}{2}$ in. thick ; let this be fixed in a vice with the broad side up, and let a coarse 15 in. flat file be laid on it lengthwise. A certain force will be required to impart longitudinal motion to the file held down on the lead with a specific weight. The particles of lead will be engaged with the teeth of the file, and before the latter can move, all the particles of lead so interlocked must be torn off the main body of the mass, and the total resistance will be found by multiplying the resistance of any one particle by the whole number of disrupted particles. If the file is loaded sufficiently to fill up all the cavities, no increase of load will practically, within certain limits, increase the resistance offered by the lead to the motion of the file. Now let us turn the bar of lead with the edge up, and laying the file *across* it, load it as before. The resistance to motion will obviously depend on the whole number of particles of lead engaged in the file teeth, and, as these cannot be more than one-tenth of the number previously engaged, if the file be

2 in. wide, it follows that the file can be moved across the bar of lead, under the conditions, with about one-tenth of the force required to move it along the bar. It must be clearly understood that in both cases the teeth of the fil eare filled up, and that no motion can take place without the abrasion of the lead over the whole surface covered by the file. Here, then, we find that the adhesion is absolutely dependent, under the conditions, on the extent of surface involved. Now, the case of a traction engine driving wheel is precisely analogous to that of our file and bar of lead—the wheel is the hard file, the road is the soft lead. If the lead were reduced in surface to a narrow edge it would offer no appreciable resistance to the file. If the bearing points of the driving wheels were reduced to a narrow line, say $\frac{1}{4}$ in. wide, across the rims of the wheels, the entire power developed by the engine must be resisted by the adhesion existing between the few particles of the road sur ace in contact with the wheel and those next below them. But there is no road in existence—not made of metal—which possesses sufficient internal cohesion to resist the strain to which it would be subjected. The upper crust would be at once torn off, and this would be succeeded by the next below, and so on until the wheel dug a pit for itself. But although two strips of road each $\frac{1}{4}$ in. wide, and 18 in. long, will not offer sufficient resistance to enable a traction engine to proceed, it is certain that they will offer *some* resistance to the rotation of the wheel, and this may be so multiplied by extension of surface that ample adhesion will be secured for all practical purposes. In this lies the advantages of the elastic wheel; it extends surface, and thereby enables a very weak and friable substance to resist a very considerable strain. Two or three Lilliputians could not have tied down Gulliver, but he must have succumbed to an army of Lilliputians. The elastic wheel simply permits us to call in the aid of an army of insignificant resistances, and to work the whole at once, whereas the rigid wheel takes them in detail and the road is beaten. Such are the general principles on which the efficiency of the elastic tire depends; we have yet to consider the action of the expedients used in connection with rigid wheels to obtain a similar result.

We had the pleasure of witnessing recently a series of experiments, which enables us to write this article in the light of the most recent information to be had on the subject.

About two years ago a committee, with Col. Galwey as president, was appointed by the Government to consider the advisability of adopting traction engines for military service. An engine, which has already been described in our pages as the "Steam Sapper," was specially constructed by Messrs. Aveling & Porter, of Rochester, for the Government, and underwent a series of exhaustive trials, with very satisf ctory results, at the hands of the committee. The conclusion arrived at was that such engines might be found very serviceable indeed, but the engine was considered to be a little too heavy for the purposes of warfare. One of the principal duties proposed for such engines was the getting of siege guns or heavy artillery into position, and it was thought proper that the weight of the engine should not exceed that of the heaviest siege gun normal to battering trains. This *was* the 95 cwt. Armstrong breech-loader. What it will be no one at present is prepared, we believe, to say. With its carriage, the gun we have named weighs about 5 tons 13 cwt., or a little less; and it is necessary to keep down the weight of the engine to at least this point, in order that the permanence of pontoon bridges especially designed to carry the guns may not be endangered. If the guns are to be got into position at all, cases may arise in which the pontoons must carry them; but it would be very awkward, to say the least, if the propelling power weighed so much that it could not go where its load could, so that for general purposes traction engines to be used in warfare must weigh as much less than 5 tons 13 cwt. as possible. To meet this necessity, Messrs. Aveling & Porter have just constructed a second "Steam Sapper," which is, we feel certain, the lightest engine of the power yet constructed, and with this engine the trials were made.

In general construction the engine is very similar to the 6-horse power engine which attracted so much attention at the Wolverhampton Show, particulars of the experiments with which have been fully reported in our pages. The boiler is

of the locomotive type, containing 106 sq. ft. of heating surface. The single cylinder is $7\frac{3}{4}$ in. diameter and 10 in. stroke. The principal difference is in the size of the tank, which holds about 78 gallons instead of 120 gallons. In all cases where strength is merely a question of dimensions these last remain unchanged. By the rigorous exclusion of every superfluous morsel of material, however, a very important reduction of weight has been effected, the new engine weighing on the Government machine in Chatham Dockyard only 4 tons 15 cwt. 3 qr. with steam up, over 1 cwt. of coal in the furnace, and 50 gallons of water in the tank. Of this weight the driving wheels carry 3 tons 14 cwt. 3 qr. In the present article we have more to do with the construction of the driving wheels of this engine than with anything else; but, as will be seen in a moment, its remarkable efficiency strongly corroborates all that has ever been advanced in these pages in favor of light and simple engines. To return, however, to the driving-wheels—these possess some peculiarities worth attention. They are all of wrought iron except the bosses, which are of cast iron, into which flat wrought-iron spokes, crossing each other, and fitted with T heads at the outer end, are cast. Before the tire is put on, the spoke ends are all turned off to the same circle, so that they abut accurately against the inside of the tire, which is of wrought iron 10 in. wide and about $\frac{5}{8}$ in. thick, stiffened by two angle iron rings, to which the spokes are fixed by two rivets in each end, in a way well understood. The weight of the engine is not supported by the rivets, but by the ends of the spokes. The tire is fitted outside with wrought iron spiral strips $2\frac{1}{2}$ in. wide by 7 in. long and about $\frac{1}{2}$ in. thick; each is secured by two good rivets with the snapheads outside. It is clear that most hard roads are convex, and it follows that the inside edges of the tires take most of the weight. In order to avoid all jolting, and to stiffen the wheels, Mr. Aveling has introduced at the inner edges in this engine a set of intermediate pieces of iron, put between the spiral strips, and secured each by one rivet. The arrangement will be understood in a moment by looking at the annexed sketch. The entire wheel is extremely light and very well made. At 9.30 A. M. a train, consisting of three wagons loaded with iron and one lorry with two heavy castings, was brought to the foot of Star Hill, Rochester, by another

FIG 1

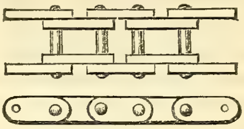


FIG 2

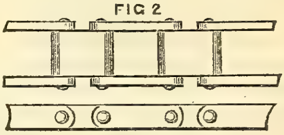
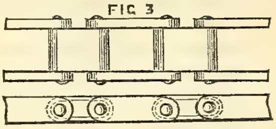


FIG 3



and heavier engine, and left there for the new engine, which, after a few moments delay, was coupled to the train and proceeded to ascend the hill in the presence of Colonel Wray and the Secretary of the Committee, Captain Clayton. The gradients of Star Hill are exceptionally severe (varying from 1 in. 75 to 1 in. 10); the surface was dry, in some places dusty, for the most part very hard, and in all affording indifferent bite. The net weight of the train was, according to the Rochester weighbridge, 15 tons 6 cwt. 2 qr. 14 lbs., made up thus:—First wagon, 4 tons; second wagon, 4 tons 10 cwt. 2 qr. 14 lbs.; third wagon, 4 tons 8 cwt.; lorry 2 tons 8 cwt. The whole train was weighed in Chatham Dockyard afterwards, with the following results: First wagon 3 tons 19 cwt.; second wagon, 4 tons 11 cwt. 3 qr.; third wagon, 4 tons 6 cwt. 1 qr.; lorry, 2 tons 6 cwt. 3 qr. 14 lbs.; total, 15 tons 3 cwt. 3 qr. 14 lbs. The disparity is due partly to the fact that the leading wagon carried a tank of water for the supply of the engine, some of which was used on the road; secondly, to the fact that some chains were transferred from one wagon to another; and lastly to the inefficiency of the Chatham Government weighbridge, which, although nominally up to 10 tons, is, we were told by the officials, unreliable when more than 3 tons are put on it. We have been thus particular, because in recording experiments on adhesion it is to the last degree important that the weights should be accurately stated. We may add

here that the inclines given were taken by the Government authorities, and are therefore reliable. The gross load, including the engine, taken up Star Hill was, by the Rochester weighbridge, and neglecting pounds, 20 tons 2 cwt. 1 qr.; by the Chatham bridge it was 19 tons 19 cwt. 2 qr. We shall for convenience assume it to have been in round numbers 20 tons, or 44,800 lbs. With this load the engine just got up without any slipping of consequence, but it is probable that on the steepest part of the hill she was loaded to the last ounce. There was a slight slip the whole way up, but except on one very dusty and rather soft bit of road, want of adhesion in no way interfered with her progress. Steam rose from 105., lbs. at starting to about 120 lbs. at the top of the hill.

The chances are, we think, about 100 to 1 that this performance is at present unparalleled. The inclines dealt with, it will be seen, vary in steepness between 1 in 22 and 1 in 11. The surface of the road was so good and hard that the resistance due to rolling friction could not well have exceeded 30 lbs. per ton, or 600 lbs. for the whole train. The resistance due to gravity, with the gross resistance for each of the gradients, is shown in the annexed table :—

Gradient.	Resistance due to gravity only.	Gross resistance, including rolling friction.
	lbs.	lbs.
1 in 22	2037	2637
1 in 16	2800	3400
1 in 14	3200	3800
1 in 11	4072	4674

In estimating the load on the driving wheels we must bear in mind that, on the one hand, the engine lost weight by standing on the inclines—to the extent on the gradient of 1 in 11 of 8.63 cwt.—but, on the other hand, the water was thrown further back, and the distribution was affected by the draught of the engine. We may assume, therefore, without much fear of error, that the load on the driving wheels going up the hill was the same as on the weighbridge. A very simple calculation then suffices to show that the engine took 5.3 times the load on the drivers up 1 in 11. There can be no dispute about this, as it was done, not only in our presence, but in that of the members of the committee. If follows, therefore, that the adhesion of the wheels we have described must have amounted on the road in question to 54 per cent. of the insistant weight.

It is beside our purpose to detail here the further trials as to handiness to which the engine was subjected. It must suffice to say that all that was expected she performed. Proceeding on her way to the dockyard, a new phase of the rigid tire system, and one which is extremely instructive, manifested itself. On the road from the railway station of the London, Chatham, and Dover line, and near the barracks, is a small bridge, pitched with ordinary paving sets, and nearly level. The road is rather worn, however, close to the part where the pavement begins, and wheels passing it have to make a of species jump ; still, it does not amount to much in the use of a train, because the wheels take it one after other, and the maximum resistance due to the jump is measured by the resistance offered to one pair of wheels. Over this bridge, however, the engine obstinately refused to take her load. On these paving sets the adhesion appeared to be reduced to about one-sixth of what it was on Star Hill. Chaining, and all kinds of devices were tried, and in the end it was with very great difficulty and after much loss of time that the engine succeeded in taking the first two wagons, weighing 8 tons 10 cwt. 2 qr., over. Once past, the pitching adhesion was restored, and engine and train proceeded up hill to the barracks, and then turned sharply up what is known as Brompton Hill, the steepest bit of which is 1 in 10. The road here is very hard and stony, and from lack of adhesion the utmost the engine could accomplish consisted in taking up the two leading wagons ; a second engine in attendance following with the other two. The train was afterwards coupled up, and proceeded without further hitch or difficulty to the weighbridge in Chatham Dockyard, returning in the afternoon to Messrs. Aveling & Porter's Works in Rochester.

We in our last impression explained that what is called adhesion in road locomotives simply consists in an interlocking of the surfaces in contact. This interlocking may be of two kinds. The asperities of the road and those of the tire may be

very small and numerous, or they may be few and large; the results obtained may, nevertheless, be the same in both cases. Again, the road may be very much harder than the tire, in which case the asperities of the former will sink into the latter; or the tire may be much harder than the road, in which case the latter will be indented instead of the former. But here again the results will be nearly the same.

Let us now compare the rigid with the elastic wheel in the light of the experiments we have just recorded. The rigid wheel is able to advance solely on the strength of its roughness. The wheels we have illustrated were nearly new and the snap heads of the rivets were sharp and well developed. They dug themselves into the hard surface of Star Hill with great energy and effect. The edges of the cross strips helped, no doubt, but a glance at the track left by the engine would suffice to convince any dispassionate observer that it was the claw-like action of the rivets that enabled the engine to ascend the various gradients passed over, on precisely the same principle that a cat climbs a tree; adhesion, in the sense ordinarily used, there was none. The damage done to the road was infinitesimal; a single horse going up with half a ton of coals in a cart would do more. In this case the road, hard as it was, was softer than the tire, and the asperities (rivets) on the latter sunk into the yielding surface. If the road had been a little softer the cross-strips would have sunk in as well as the rivets, and an additional bite would have been obtained. If, on the other hand, a Thomson tire had been used, the asperities of the road would have sunk into the tire, and the adhesion would possibly have been just as great with india-rubber as with soft iron, though the mode of action of the two would have been essentially different.

The question remains to be considered, which is the best material for a traction engine tire—india-rubber or iron? If we take the great cost of india-rubber tires—amounting as it does, to £200 for a pair of 6 ft. tires, 14 in. wide—into account, then it is indisputable the iron is the best. If, however, we handle this question in a purely mechanical way, and neglect all considerations of cost, it will be seen that on the whole, the india-rubber tire is the best, for the following reasons:—We have pointed out that without a mutual interlocking of the road and the tire there can be no adhesion. The rigid tire is designed on the presumption that the road will always be softer than the tire, and this proposition is generally true; it is, however, impossible to secure that it shall invariably be true. But when a rigid tire meets with a bit of road equally hard, adhesion becomes evanescent. The tire cannot bite the road, the road cannot bite the tire. The engine fails to proceed precisely in the same way that a cat fails to climb a polished iron pillar; and for this reason the "Steam Sapper No. 2" failed, as we have explained, to take her load across the paved bridge. It may be urged that such bits of road are exceptional; but granting this—although it is not quite true—the balance of advantage is still in favor of india-rubber, because as the strength of a chain is only that of the weakest link, so a traction engine might totally fail to accomplish the purpose for which it was intended if 100 yards of paved road were encountered in a run of 100 miles. It is impossible to secure the invariable presence of a road softer than the tire; but it is possible to secure the presence of a tire which shall be more yielding than any highway in existence by the use of india-rubber; and it, therefore, appears to be on the whole better that the road should indent itself into the tire than that the tire should indent itself into the road.

But the question cannot be settled on this basis alone; there is another point to be considered. The rigid wheel depends for the manifestation of great powers of traction solely on the roughness of its surface. Therefore, a wheel which is just out of the maker's hands may do excellent work, and yet be rendered comparatively useless in a week. The chances are that, after a fortnight's continuous service, "Steam Sapper No. 2" will be utterly unable to get up Star Hill with more than ½ the load she took up on Tuesday. The rivets will be all worn down and the corners rounded off the cross-strips. It must not be forgotten, however, that at a very moderate outlay the original efficiency of the wheels can be restored by merely putting in new rivets. No such difficulty can arise with india-rubber tires. So long as a road exists it is certain to be rough, and if we carry the soft ma-

terial in the shape of india-rubber with us, all will go right. The drawback is the enormous cost of the rubber.

It is quite certain that nothing like the most has yet been made of rigid wheels. Builders of such engines may take a lesson from any maker of ploughshares in the art of producing wheels the asperities on which shall always be sharp and capable of biting the ground until the wheel is pretty nearly worn out. In the matter of rivets alone there is a great field for improvement. No one now thinks of fixing an eccentric with pointed set screws, sunk-ended screws being always used for the purpose, because if shifted ever so little, they take a fresh grip; but no one ever saw a sunk-ended rivet used in a traction-engine wheel. This, and a great many other things have to be learned before the rigid wheel is made all that it can be made; and, after all, it is possible that an elastic wheel, possessing its advantages and none of its disadvantages, may be produced at the price of the improved rigid wheel. Be this as it may, it is certain that each day is adding to the stock of information concerning traction engines; every experiment made with them is more encouraging than the last, and affords fairer and yet fairer promise of the attainment of an ultimate success greater than is now held to be possible, except by a very few, among whom we beg to include ourselves.

And here we bring our series of papers on the construction of traction engines to a conclusion, at least for the present. We have done, we know, little more than state a few of the general principles which should guide engineers in their design and construction. The literature of the subject is meagre to the last degree. We have written in the hope that our very moderate contribution to it may prove of service, especially to our younger readers. It still remains as much as ever our duty to record in our pages every improvement that may be effected in a most interesting, attractive, and important branch of mechanical engineering.

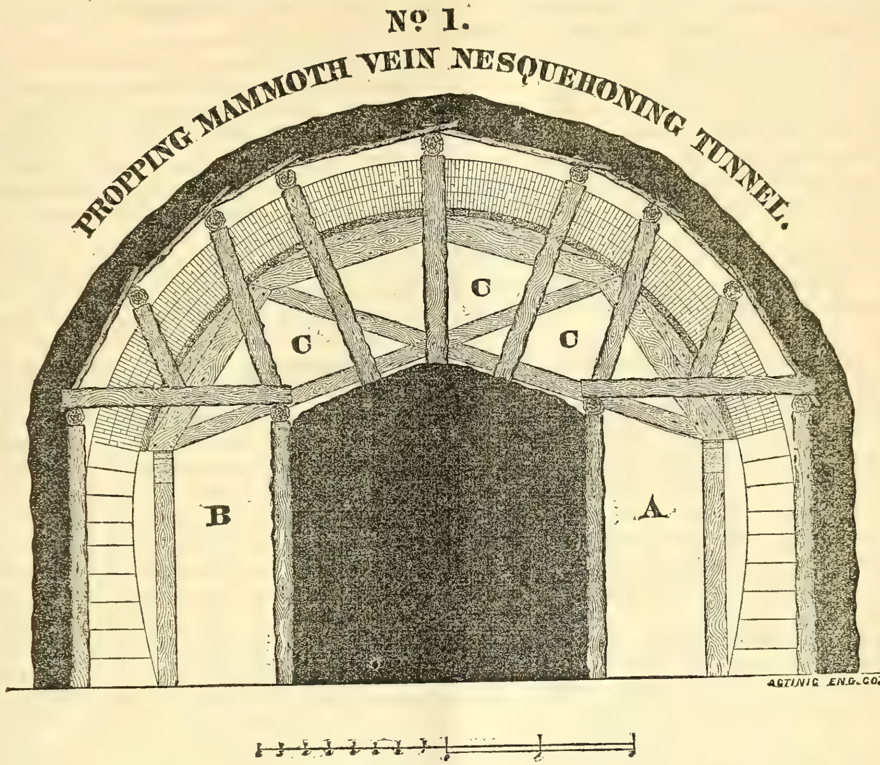
NESQUEHONING TUNNEL.

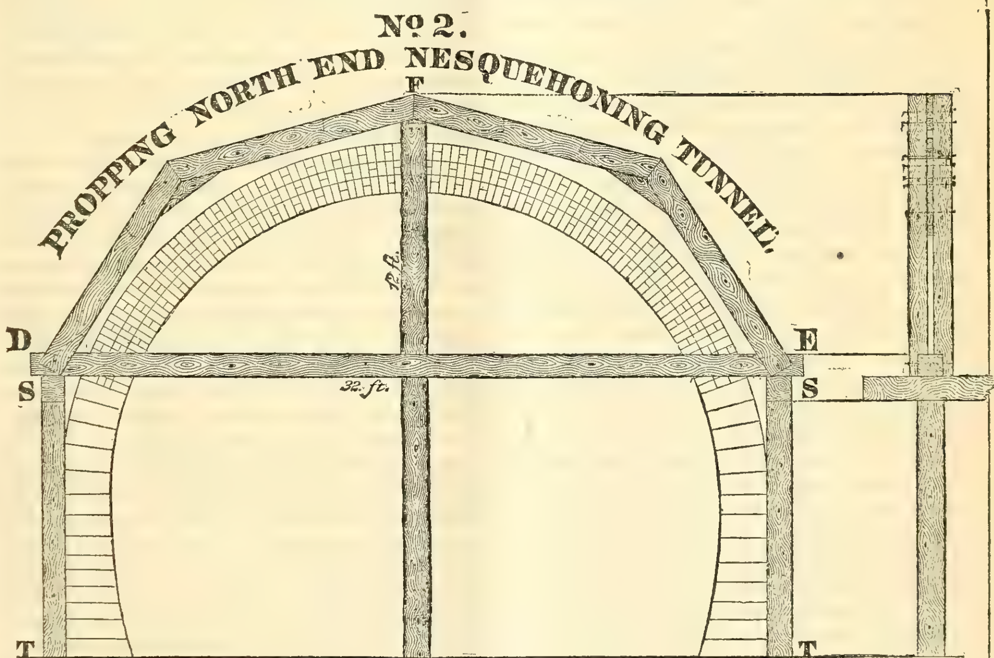
From "Transactions of American Society of Civil Engineers."

Nesquehoning Tunnel, in Carbon County, Pennsylvania, is a work of the Lehigh Coal and Navigation Company. It pierces Locust Mountain, and will connect their railroad in Nesquehoning Valley with their extensive coal operations in the valley of Panther Creek. At present this coal finds its way to market by that interesting system of inclined planes and gravity roads known as the "Switch-backs of Mauch Chunk," which has commanded the admiration of travellers for more than 40 years, not only on account of the beautiful scenery which the route displays, but also from its early and admirable adaptation to the purpose for which it was designed. It has, however, become worked up to its capacity, and in arranging to extend their coal mining operations, the Company have wisely determined to avail themselves of the locomotive, which has had its practical development since they were the pioneers in railway enterprise.

It passes through the base of the mountain at an elevation of some 15 ft. above the water on either side, and 554 ft. below the crest, and cuts the strata at right angles, where they have a south dip of about 45 deg. Its length in 3,800 ft., of which 1,300 ft. are through the coal-measures, with all their various strata of coal, coal-shale, sandstone, and conglomerate; 1,200 ft. through the conglomerate formation, with its occasional strata of coal-slates and sandstone; 1,000 ft. through the red shale, with occasional strata of sandstone, and 300 ft. at the north end through the debris, and soft and decomposed red shale which is found overlaying the red shale formation. It has encountered in its progress as hard and as soft material as is often met with in tunnelling.

After mature investigation it was determined to use the Burleigh Drills, driven by compressed air. With the advantage of the experience at Mont Cenis and Hoosac before us, we should, and it is believed we have obtained better results, as to cost and progress, than attended either of those works in their early stages, and I may here state that I believe no other known process is capable of pene-


No 1.
PROPPING MAMMOTH VEIN NESQUEHONING TUNNEL.
C
C
C
B
A
ACTINIC ENG. CO.


No 2.
PROPPING NORTH END NESQUEHONING TUNNEL.
F
12 ft.
D
E
S
S
32 ft.
T
T
ACTINIC ENG. CO.

trating this conglomerate formation, with that economy and rapidity which is necessary to meet the present demands of capital. This whole work has been done with 6 of the "two-drill" compressors, made at Fitchburg, Mass., and with 16 drill engines, and we have averaged as much as one-half of the drill engines constantly in operation, and sometimes two-thirds.

The explosive used was gunpowder, ignited by the electric spark; but the requirements of ventilation, and the hardness of the rock, demanded powder of the highest Government standard. Some doubts which existed as to the economy in the use of the more powerful explosives, when the cost of drilling was reduced by machinery, and their greater danger, with the existing knowledge of workmen of their use, caused them to be rejected, and the result in the freedom from serious accident has been satisfactory, as we have not, thus far, lost a life from premature explosions.

American steel has been used; several of our own makers produce a better and cheaper article for the purpose than can be obtained from abroad, and the best we have had is from the William Butcher Steel Works at Philadelphia.

The headings are driven at the bottom, 8 ft. high by 16 ft. wide, and where arching is required, the full width for a double track is taken ont, that the tunnel may hereafter be enlarged, without disturbing the arches. At this date both headings are in the red shale, and about 500 ft. apart; they will be joined in August, and, until the tunnel is finished, full details of the work cannot be given; but the accompanying statement of Thos. C. Steele, chief assistant-engineer of the operations at the south end, up to June 1st, may be of some interest.

The heading to which the tabular statement refers, has been 12 months in the conglomerate, and 2 months in the red shale; the progress in the conglomerate has been about 100 ft. per full month's work, and in the red shale 160 ft. The holes drilled per cubic yard of rock removed, have been in the conglomerate about 11 ft., and in the red shale about $6\frac{1}{2}$ ft. The powder used per cubic yard has been in the conglomerate about 6 lbs., and in the red shale about $3\frac{1}{2}$ lbs., though a bad lot of powder ran the consumption in the conglomerate up to $7\frac{1}{2}$ lbs. for two months.

The operation in the enlargement, to which the statement refers, has been 8 months in the coal measures, and 2 months in the conglomerate; its average monthly progress has been 166 ft.; its average holes drilled, per cubic yard of rock removed, $3\frac{3}{10}$ ft.; and its average powder used $2\frac{7}{10}$ lbs. per cubic yard.

In this enlargement a portion of hand-drilling is included, which extended over the operations of one month, and it increased both the holes drilled, and the powder consumed, showing that men do not use better judgment in directing hand than machine drilling. The Mammoth Coal Vein in this region is 50 ft. in thickness, and where it was cut by the tunnel, it was crushed, or to use a miner's expression, it was "in fault," and great care was necessary to prevent a "run," or to be more explicit, to prevent this crushed coal from running into the tunnel, its inclination being 45 deg. If a run had started, it would probably have extended to the outcrop, a height of 400 ft. The plan marked No. 1 will show the mode of propping. The galleries A and B, were first driven, and the masonry abutments built in them, after which the cutting over at C C C was done, leaving a core in the centre to prop upon, which being effected, the brick arch was turned, and the centre removed. The same plan was substantially followed in other coal veins.

The North Approach was excavated through the debris, which was about the same weight as water, and as there was a considerable flow of water into the cutting, and over the top of the soft red shale, its agitation in the process of excavation converted it into quicksand, and caused some trouble in its removal (with the slides and sinks usual in such cases), as well as in starting the tunnel. The depth of excavation at the north portal is 65 ft., and the lower half of the tunnel at that point is in soft red shale in place, and the upper half in the debris, with the flow of water referred to upon the top of the red shale. To those accustomed to such work, I need not relate the difficulties of the position. In order to effect an entrance there was first turned a strong façade of masonry, with an arch of 15 ft. in depth, abutting against the face of the excavation; the heading was then started upon the top of

soft red shale, 32 ft. in width and 12 ft. in height, an unusal size for a soft ground heading. The Plan No. 2 will indicate the mode of propping; plank shields were placed in the face of the heading, to prevents its running, and the frames D, E, F, wh plank lagging and fore poling, were put in at a distances of 3 to 4 ft. from centre to centre, resting at their base, D, E, upon the more solid red shale. This operation was continued a distance of 340 ft., and until solid rock was met, with the full depth of the tunnel. The next operation was to slip the sills S, S, by a careful process, under the base of the frames, to cut away for the props, S, T, and to put in the stone abutments and brick arches, packing them carefully on the top with the rock from the tunnel excavation. When the frost was leaving the ground last spring, the superincumbent mass came down with crushing effect upon the framing, but they resisted its influence, and have since been strengthened by the arches.

STATEMENT OF THE WORKINGS OF THE SOUTH END OF NESQUEHONING TUNNEL.

Heading.

MONTH.	Feet of Holes Drilled.	Lbs. of Powder used.	Feet Progress.	Cubic Yards Progress.	Feet of Holes per Cubic Yard.	Lbs. Powder per Cubic Yard.
1870.						
April	2740	1125	73.	413.	6.6	2.7
May	6698	2725	138.	781.	8.6	3 5
June	6779	4200	104.	589.	11.5	7.1*
July	5862	4275	97.5	553.5	10.5	7.7*
August	5179	2750	82.	464.7	11.1	6.0
September	4920	2625	72.5	410.8	11.9	6.4
October	6052	2525	91.	520.	11.6	4 9
November	5054	2700	103 5	586 5	8 6	4.6
December	4638	2400	78.	442.	10.5	5.4
1871.						
January	5438	2900	101.	496.	11.0	5 8
February	6161	2825	93 5	530.	11.6	5.3
March	6043	3400	104.	589.5	10 2	5.8
April	6114	3000	157.	890.	6 8	3 4
May	5793	3600	164.	928.	6 3	3 9
Total	77471	41050	1459.	8194.	9.4	5.0

* Bad Powder. Average, 104.

Enlargement.

MONTH.	Feet of Holes Drilled.	Lbs. of Powder used.	Feet Progrees.	Cubic Yards Progress	Feet of Holes per Cubic Yard.	Lbs. Powder per Cubic Yard.
1870.						
August	2223	1450	125.	1000.9	2.2	1.4
September	2584	2125	123.5	905.7	2 9	2.3
October	3491	2650	153 5	1237.	2.8	2 1
November	4408	2700	120.	1276.5	3 4	2.1
December	4410	5775	156.	1002.	4.4	5.7*
1871.						
January	3667	3075	164 5	1158.	3 2	2.7
February	3432	3900	265.	1701.	2 0	2.3
March	5316	3900	215.5	1359.5	3.9	2.9
April	2633	1900	195 5	666.	4 0	2.9
May	4438	2600	145.5	873.	5.0	2.9
Total	36602	30075	1664.	11179.6	3.3	2.7

* Partly Hand Drilling. Average, 166.

Mr. F. C. Collingwood succeeded Mr. Steele, with some observations on the East River Bridge foundation.

RECENT RESEARCHES ON FLIGHT.

From the "English Mechanic and World of Science"

Mr. J. Murie has an article on this subject in a recent number of "Land and Water." Of late, says the author, the perplexing problem of flight has received a greater amount of attention from physiologists and savants than has been bestowed upon it for years, and the result of their researches and experiences is in a fair way of becoming remarkable for its fruit-bearing character. Whilst abroad, such men as Borelli, Straus-Durckheim, Charier, Girard, and Marey, have severally given to the world the gist of their labors in this branch of science; at home, the Duke of Argyll and Dr. J. Bell Pettigrew have awakened our deep interest by their views on natural and artificial flight. To the latter is due the honor of giving birth to the celebrated "figure-of-8 wave theory," that is now attracting so much notice in our aeronautical schools

As early as 1867, Dr. Pettigrew delivered, before the Royal Institution of Great Britain, a lecture in which he propounded that novel theory, and in 1868 he published in the "Transactions" of the Linnean Society an elaborate memoir on "The Mechanical Appliances by which Flight is Attained in the Animal Kingdom." The year after, Professor J. E. Marey, in the "Revue des Cours Scientifiques," bore out Dr. Pettigrew's ideas, by the detail of his experiments with the sphygmograph, with which he succeeded in causing the wings of insects and birds to register their own movements. He says: "But if the frequency of the movements of the wing vary, the form does not vary. It is invariably the same; it is always a double loop, a figure of 8. Whether this figure be more or less apparent; whether its branches be more or less equal, matters little; it exists, and an attentive examination will not fail to reveal it." An indefatigable worker, Dr. Pettigrew continued, without pausing, the task to which he had set himself—and that to him is indeed a labor of love; and in this year's "Transactions of the Royal Society of Edinburgh," we have from his pen a complete monograph on "The Physiology of Wings," in which he treats with equal felicity of both natural and artificial flight. The mass of interesting facts brought to light by the author is too copious to allow of lengthened discussion, but from it we abstract the following items:—

The wing is generally triangular in form. It is finely graduated, and tapers from the root towards the tip. It is likewise slightly twisted upon itself, and this remark holds true also of the primary or rowing feathers of the wing of the bird. The wing is convex above and concave below; this shape, and the fact that in flight the wing is carried obliquely forward like a kite, enabling it to penetrate the air with its dorsal surface during the up stroke, and to seize it with its ventral one alike during the down and up strokes. The wing is movable in all its parts; it is also elastic. Its power of changing form enables it to be wielded intelligently, even to its extremity; its elasticity prevents shock, and contributes to its continued play. The wing of the insect is usually in one piece, that of the bat and bird always in several. The curtain of the wing is continuous in the bat, because of a delicate elastic membrane which extends between the fingers of the hand and along the arm; that of the bird is non-continuous, owing to the presence of feathers, which open and close like so many valves during the up and down strokes.

The posterior margin of the wing of the insect, bat, and bird is rotated downwards and forwards during extension, and upwards and backwards during flexion. The wing during its vibration descends further below the body than it rises above it. This is necessary for elevating purposes. The distal portion of the wing is twisted in a downward and forward direction at the end of the down stroke, whereas at the end of the up stroke it is twisted downwards and backwards. The wing during its vibrations twists and untwists, so that it acts as a reversing reciprocating screw. The wing is consequently a screw, structurally and functionally. The blur or impression produced on the eye by the rapidly oscillating wing is twisted upon itself, and resembles the blade of an ordinary screw-propeller. The twisted configuration of the wing and its screwing action are due to the presence of figure-of-

8 looped curves on its anterior and posterior margins; these curves, when the wing is vibrating, reversing and reciprocating in such a manner as to make the wing change form in all its parts.

We may further point out that Dr. Pettigrew has not based his ideas on the structure of wings on mere theoretical considerations. Besides elaborate anatomical examination, he has entered with a true experimental spirit into a close study of the visible movements of most of the winged tribe. The very excellent diagramatic views with which his paper is elaborately illustrated, convey at a glance much that is difficut to express in words. In proof of this, the reader need but compare those figures bearing on the wing movements of the butterfly, the dragonfly, and the bird.

On these and similar deductions from the practical study of natural history, Dr. Pettigrew bases his elements of artificial flight. These are in themselves so interesting and new that we must defer a notice of them to another occasion.

STRENGTH OF GIRDERS TESTED BY MODELS.

By KOPKA.

Translated from "Der Civil Ingenieur."

On account of the uncertainty of the coefficients of strength and their variation, due to different conditions of temperature and moisture, to repeated bendings, shocks and vibrations, the theoretic determination of the dimensions of girders is not always to be relied on ; so that it is desirable to test proof-strength and durability by means of a model.

The measurements of the tensions and pressures in the verticals and diagonals of the model of a bow-string girder, by means of the sound of a stretched wire—made by Airy, some years since, are very suggestive, both at first glance and upon closer examination.

It is not to be denied that a model which, with proportional load, shows strains proportional to those of a large girder is of much use, and that questions not answerable by calculation may find solution in it. But the construction of such models is attended with great difficulties, and, instead of dispensing with the theory of girders, requ res a still more refined development.

It is matter of regret that in the account of Airy's experiments there is no proof that his model showed strains derivable from or equal to the corresponding depressions, stretchings and compressions in the actual bow-string girder. Suppose this proof supplied ; then there should be experiments with greater span, and corrections should be made of the calculated results for the bow-string girder and for trusses subject only to tension and compression ; the effect of small strains, as upon nuts, being neglected.

Calculation gives us no means for determining the effect of slight bendings continued during 100 years' use of the girder; while a model showing corresponding strains at corresponding points might solve the problem ; if by means of some simple mechanism it were subjected to the same number of depressions in the course of a few weeks. In like manner, the resistance of girders under shocks and changes of temperature might be determined.

Airy's plan is therefore not to be rejected ; but great pains must be taken that the model corresponds in development of strains with the projected girder. Otherwise great errors may be made, as will appear. But the laws of construction of such models are not simple ; and the writer, in investigating them in the case of ordinary trusses, found such difficulty that he determined to examine the cases of the simplest girders.

For this kind of girder the model must be adjusted so that all sections are $\frac{1}{n}$th of the natural magnitude, and dimensions in length are $\frac{1}{\sqrt{n}}$th of the original ; so that two standard measures are employed.

Measuring the proof-load not by pounds, but by the weight g of the model, and the projected load of the girder by its proper

weight G, we find that in model and girder for equal load-numbers at corresponding points there occur equal tensions and equal depressions; and the breaking point in model and girder occurs at the same place.

The same holds, if measuring all loads by g and G, the model were constructed according to the following standards, which, however, are useless in actual practice:—for the profile breadth, $\frac{1}{n}$th of natural size; for profile depth, $\frac{1}{n^2}$; and for length, $\frac{1}{n}$th. The above principle, then, is strictly expressed as follows: "A model with depth measure in the ratio of the square of the length and of the breadth measures, and which—its own weight being taken as the unit of weight—is loaded just like the girder, shows at corresponding points the same tension of fibre; and the depressions of model and girder are equal."

The investigation for framed and for free girders with any load is easily made, by representing model-numbers by small figures, and girder numbers by large; distinguishing again the latter from the former by use of the coefficient n. Hence the proper weight of girder

$$G = gn^2\sqrt{n}$$

the length

$$L = l\sqrt{n}$$

the moment of resistance of symmetric or unsymmetric section

$$W = wn^3$$

the abscissa

$$X = x\sqrt{n}$$

If q_1, q_2, q_3, &c., represent the distributed loads in pounds, the fractions

$$\frac{q_1}{g},\ \frac{q_2}{g},\ \frac{q_3}{g},\ \text{\&c.,}$$

are used for the model; and

$$\frac{Q_1}{G},\ \frac{Q_2}{G},\ \frac{Q_3}{G}$$

for the girder; writing, instead of the fractions, z_1, z_2, z_3, &c., and Z_1, Z_2, Z_3.

Now, if the girder is to bear at a certain point Z times the weight G, the model must be loaded with Z times the weight of g; and hence we always have

$$\frac{q_1}{g} = Z_1 = \frac{Q_1}{G} = Z_1$$

or

$$\frac{q_2}{g} = z_2 = \frac{Q_2}{G} = z_2\text{, \&c.}$$

Tension of Fibre.

Let σ = the tension of the external fibre;

w = the moment of resistance $= \frac{r}{e}$;

g = the weight of model;

then for free and also for framed beams we have

$$m_x = ax - \left(\frac{qx_2}{2l} + m_1 + m_2 + \ldots + m_0\right) = \sigma w_1$$

x being the abscissa of a point n, Fig. 1, $m_1 + m_2 +$, etc., being the load moment about n as centre, and m_0 the moment of the abutment or point of support. For free abutment this last moment is zero.

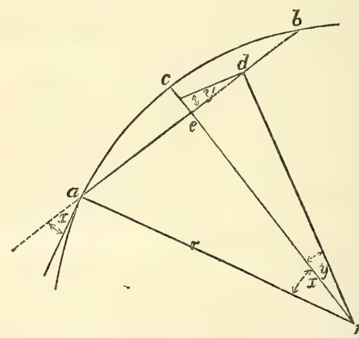
Hence the tension of the external fibre at a point whose abscissa is x is on the model

$$\sigma = \frac{1}{w}\left[ax - \left(\frac{qx^2}{2l} + m_1 + m_2 \ldots m_0\right)\right], \quad 1)$$

in the girder

$$\Sigma = \frac{1}{W}\left[AX - \left(\frac{GX^2}{2L} + M_1 + M_2 + \ldots M_0\right)\right]. \quad 2)$$

Fig. 1.



Comparing moments, we have for any moment in the model m_v

$$m_v = q_v\,(x - l_v)$$

or if

$$\frac{q_v}{g} = z_v$$

$$m_v = z_v\,(x - l_v)\,g.$$

and in the girder

$$M_v = Z_v\,(X - L_v)\,G, \quad \text{or since } Z_v = z_v$$

$$= z_v\,(x - l_v)\,g\,n^3,$$

or

$$M_v = m_v\,n^3. \quad 3)$$

Hence

$$\frac{G\,X^2}{2\,L} = \frac{g\,x^2}{2\,l}\cdot n^3. \quad 4)$$

Representing by m and M the moments of single loads referred to the other bearing point we have generally, in the model,

$$a = \frac{m_0 + m_1 + m_2 + \ . \ . \ . \ . \ + g\frac{l}{z}}{L}$$

in the beam,

$$A = \frac{M_0 + M_\Phi + M_2 + \ . \ . \ . \ . \ + G\frac{L}{z}}{L}$$

or from (3) and (4) $A = a n^2 \sqrt{n}$.
Substituting from (3) (4) (5) in (2) the tension in the abscissa X,

$$\Sigma = \frac{n^3}{W}\left[ax - \left(\frac{gx^2}{2l} + m_1 + m_2 + \ . \ . \ . \ m_0\right)\right]$$

or, since for symmetric and unsymmetric section $W = w n_3$,

$$\Sigma = \frac{1}{w}\left[ax - \left(\frac{gx^2}{2l} + m_1 + m_2 + \ . \ . \ . \ m_0\right)\right]$$

that is, with reference to equation (1), is just as great as in the model.

From the equality of the external fibre-tension for corresponding profile, there follows, according to known laws, the equality of the fibre-tension for every corresponding point of the profile; and hence the point of rupture, or the place where the tension of the external fibre is at its maximum, must lie as in corresponding points of the model.

Deflection.

Let t = the moment of inertia
y = the deflection corresponding to the abscissa x
$q_1, q_2, \ldots$ = the distributed loads in pounds, then the equation of the elastic line is

$$t\,E\frac{d^2y}{dx^2} = m_x$$

or expanding,

$$t\,E\frac{d^2y}{dx^2} = ax - m_0 - q_1(x-l_1) - q_2(x-l_2) \ldots - \frac{gx^2}{2l}.$$

Integrating;

$$t\,E\frac{dy}{dx} = \frac{ax^2}{2} - m_0x - q_1\left(\frac{x^2}{2} - l_1x\right)$$
$$- q_2\left(\frac{x_2}{2} - l_2x\right) \ldots - \frac{gx^3}{6l} + c$$

and

$$t\,E\,y = \frac{ax^3}{6} - m_0\frac{x^2}{2} - q_1\left(\frac{x^3}{6} - l_1\frac{x^2}{2}\right)$$
$$- q_2\left(\frac{x^3}{6} - l_2\frac{x^2}{2}\right) \ldots - \frac{gx^4}{24l} + cx + c_1.$$

Let q = weight of model; then since $z = \frac{q}{g}$

$$t\,E\frac{dy}{dx} = \frac{ax^2}{2} - m_0x - z_1g\left(\frac{x_2}{2} - l_1x\right)$$
$$- z_2g\left(\frac{x^2}{2} - l_2x\right) \ldots - \frac{gx^3}{6l} + c \quad . \ . \ . \ 1)$$

$$t\,E\,y = \frac{ax}{b} - M_0\frac{x^2}{2} - z_1g\left(\frac{x^3}{6} - l_2\frac{x^2}{2}\right)$$
$$- z_2g\left(\frac{x^3}{6} - l_2\frac{x^2}{2}\right) \ldots - \frac{gx^4}{24l} + cx + c_1 \ . \ . \ . \ 2)$$

For the girder; substitute large letters.

$$T\,E\frac{dY}{dX} = \frac{AX^2}{2} - M_0X - \text{etc.} + C. \quad 3)$$

$$T\,E\,Y = \frac{AX^3}{6} - M_0\frac{X^2}{2} - \text{etc.} + CX + C_1. \quad 4)$$

Putting instead of (1)

$$t\,E\frac{dy}{dx} = F_x + c$$

and for (3) $T\,E\frac{dY}{dX} = F_x + C$

and changing x_1, y_1, into X_1, and Y_1, the co-ordinates of the point of greatest depression, we have

$$\frac{dy}{dx} = \frac{dY}{dX} = o$$

and hence, for model

$$(F_x)^{x=x_I} = -c, \quad . \ . \ . \ . \ . \ 5)$$

for girder,

$$(F_x)^{X=X_I} = -C. \quad . \ . \ . \ . \ . \ 6)$$

But from (3), (4) and (5)

$$\frac{AX_I^2}{2} = ax_I^2\,n^3\sqrt{n}$$

$$M_0X_I = m_0x_I^2\,n^3\sqrt{n}$$

$$Z_1G\left(\frac{X_I^2}{2}L_1X_I\right) = n^3\sqrt{n}\,.\,z_1g\left(\frac{x_I^2}{2} - l_1x_I\right)$$

$$\ldots\ldots = n^3\sqrt{n}\ldots\ldots$$

$$\ldots\ldots = n^3\sqrt{n}\ldots\ldots$$

and finally

$$\frac{GX_I^3}{6L} = n^3\sqrt{n}\,.\,\frac{gx_I^3}{6l}.$$

Substituting in (3) and comparing with (1)

$$F_{XI} = n^3\sqrt{n}\,.\,F_{xI}$$

and from (5) and (6)

$$C = cn^3\sqrt{n}. \quad . \ . \ . \ . \ . \ 7)$$

Instead of (2) and (4) put

$$t\,E\,y = \phi_x + c_1$$
$$T\,E\,Y = \Phi_X + C_1,$$

then for

$$x = l \text{ and } X = L,\ y = Y = 0$$

and for model

$$(\phi_x)^{x=l} = -c_1. \ 8)$$

for girder

$$(\Phi_X)^{X=L} = -C_1 \quad 9)$$

From (3), (4), (5) and (7) we have

$$\frac{A X_L{}^3}{6} = \frac{a x_l{}^3}{6} \cdot n^4 \qquad \frac{M_0 X_L{}^2}{2} = \frac{m_0 x_l{}^2}{2} \cdot n^4$$

$$Z_1 G \left(\frac{X_L{}^3}{6} - \frac{L_1 X_L{}^2}{2}\right) = z_1 g \left(\frac{x_l{}^3}{6} - \frac{l_1 x_l{}^2}{2}\right) n^4$$

$$\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots n^4$$

$$\ldots\ldots\ldots = \ldots\ldots\ldots\ldots\ldots n^4$$

$$\frac{G X_L{}^4}{24 L} = \frac{g x_l}{24 l} \cdot n^4$$

$$C X_L = c x_l \cdot n^4.$$

Substituting in (4) and comparing with (2)

$$\Phi_{XL} = n^4 \phi_{xl}$$

and $C_1 = c^1 n^4 \quad . \quad . \quad . \quad . \quad . \quad 10)$

If $Z_1 = z^1$, &c., is the general equation.

$$TEY = \frac{AX^3}{6} - \frac{M_0 X_2}{2} z_1 G \left(\frac{X^3}{6} - L_1 \frac{X_2}{2}\right) \ldots$$

$$- \frac{GX^4}{24 L} + CX + C_1.$$

For symmetric and unsymmetric sections $T = tn^4$ and

$$A = an^2 \sqrt{n} \qquad G = gn^2 \sqrt{n}$$

$$X = x\sqrt{n} \qquad C = cn^3 \sqrt{n}$$

$$M = m_0 n^3 \qquad C_1 = c_1 n_4$$

$$L, \text{ etc. } = l_1 \sqrt{n}, \text{ etc.}$$

Substituting these values in Eq. 11 for the beam, and comparing the result with Eq. 2 for the model, we have for the depression for the abscissa X, $Y = y$; that is, just as great as in the model at the corresponding point.

IRON AND STEEL NOTES.

FINISHING STEEL.—Of all the methods or processes of working and finishing steel, probably there is none extensively used about which there is so little known by mechanics in general as that of the "friction-wheel," and this lack of knowledge has no doubt kept its use confined within the bounds of almost a single class of work. It is generally known that the smooth edge of a soft steel or iron wheel, when run at a high speed, will cut tempered steel, soft steel, iron, and other substances very rapidly, but with it goes the belief that steel so cut is practically ruined for all useful purposes. This is true only to a certain extent, and is entirely avoidable by a proper speed of the friction wheel and a skilful operator. A smooth steel wheel running with a periphery speed of from two to three miles per minute, will cut steel at a rapid rate, and without heating it to such an extent as to even change the color; the cutting wheel, too, retaining its form for a great length of time without being returned. Not only the spiral sides of augers and auger bits are smoothed out and finished by friction-wheels, but the fine screw points of the same are wholly formed by the sharp edge of a soft steel plate run at the frightful speed of 14,000 revolutions a minute. The freedom from heating or burning the work, as well as the accuracy and beauty with which it is done, is unquestionably in a great measure due to the skill of the operator; still this skill may be matched by the skill of the inventor, and the friction wheel applied to hundreds of purposes yet unthought of.—*Mechanics' Magazine.*

WIRE ROPE MANUFACTURE.—The wire rope works of Messrs. John A. Roebling's Sons, at Trenton, New Jersey, are the largest in the United States, occupying an area of 10 acres, located on the Delaware and Raritan Canal, and connected with the Camden and Amboy Railway. Bright wire, steel, and galvanized wire rope, in all sizes and length, are made, and the machinery is capable of making as large wire rope as can be manufactured. One piece, 5,870 ft. long, weighing 62,000 lbs., was recently made for the Lehigh and Susquehanna Railway, costing $10,540. The business was first started in 1849 by the late Mr. John A. Roebling, and now employs 125 hands, and 3 engines, giving in all 350-horse power. A rolling mill, in connection with the works, has a capacity for 40 tons of wire per week. A new building, to be 200 by 40, is now being built for a galvanizing house. The class of work turned out at this establishment is second to none in the world, as the results at the Niagara Falls and other suspension bridges fully prove. This wire will be used in the great East River Bridge now being constructed by the Messrs. Roebling.—*American Railway Times.*

IRON MAKING IN WISCONSIN.—Mr. Greeley, in some brief notes on Wisconsin, furnished the "Tribune," says great discoveries of iron ore have recently been made, mainly in the great wilderness stretching eastward from the Menominee, and several blast furnaces have been erected, mainly on or near Green Bay, though by far the largest is located at Milwaukee. As yet, those in the northern counties use Lake Superior ore costing 7 per ton, and melt it with charcoal costing 9 cents per bushel, making each ton of metal cost $28; and since its price in Chicago is but $33, the profit is small; but cheaper ores will doubtless be found and used, insuring a cheaper product and perhaps larger profits.—*American Railway Times.*

THE New Jersey Steel and Iron Company ranks among the largest establishments of the kind in the United States, and for the present is the largest manufacturing company in Trenton, N. J., employing 550 men. This is an incorporated company, and their property and machinery is valued at $750,000. Rolled wrought iron beams and bars, and iron and steel-headed rails, merchant iron and the Martin steel are among the products of this mill. The works occupy 12 acres, and are very extensive. The annual capacity of the mill is for 20,000 tons of rails, of 10,000 tons of beams, for flooring, bridges, etc. The flooring beams for the New York City Post Office are furnishd by this company. They have the exclusive control in the United States of the right to manufacture the Martin steel, under a French patent, and have one

furnace producing 5 tons at a charge. Their steel is used mostly for engine and machine work.—*American Railway Times.*

THE following table shows the average monthly and yearly prices of Anthracite Pig Iron No. 1, tons of 2,240 lbs., from 1860 inclusive to the present time ; from weekly quotations in Philadelphia and New York prices current :

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Year.
1860	23	23	$23\frac{17}{40}$	$22\frac{3}{8}$	$22\frac{3}{4}$	$22\frac{3}{4}$	$22\frac{3}{4}$	$22\frac{1}{2}$	$22\frac{1}{4}$	$22\frac{3}{8}$	$22\frac{3}{4}$	$22\frac{1}{2}$	$22\frac{3}{4}$
1861	$22\frac{1}{8}$	$21\frac{3}{4}$	$21\frac{1}{4}$	$21\frac{7}{8}$	$21\frac{1}{8}$	$20\frac{1}{2}$	$19\frac{7}{8}$	$18\frac{7}{10}$	$18\frac{11}{16}$	$18\frac{5}{8}$	$18\frac{9}{10}$	$19\frac{5}{8}$	$20\frac{1}{4}$
1862	20	$20\frac{3}{4}$	$20\frac{3}{4}$	$21\frac{1}{2}$	$21\frac{1}{2}$	$22\frac{3}{4}$	24	$24\frac{3}{8}$	$24\frac{1}{2}$	$25\frac{1}{4}$	$30\frac{1}{4}$	$31\frac{1}{8}$	$23\frac{7}{8}$
1863	32	$33\frac{1}{4}$	$35\frac{1}{2}$	36	$34\frac{3}{4}$	$33\frac{1}{2}$	$32\frac{3}{4}$	$31\frac{3}{4}$	33	$35\frac{3}{4}$	$41\frac{1}{16}$	$43\frac{1}{2}$	$35\frac{1}{4}$
1864	$43\frac{3}{20}$	$48\frac{5}{8}$	$50\frac{1}{8}$	$54\frac{1}{2}$	$57\frac{1}{4}$	$57\frac{5}{8}$	$69\frac{1}{10}$	$73\frac{5}{8}$	$72\frac{1}{4}$	$63\frac{4}{5}$	$61\frac{1}{2}$	$59\frac{1}{10}$	$59\frac{1}{4}$
1865	$58\frac{1}{8}$	$53\frac{1}{8}$	$50\frac{3}{8}$	$45\frac{1}{2}$	$39\frac{1}{8}$	35	$35\frac{3}{5}$	$40\frac{1}{8}$	$44\frac{3}{10}$	$49\frac{7}{8}$	51	$50\frac{4}{5}$	$46\frac{1}{8}$
1866	$50\frac{3}{8}$	49	$46\frac{1}{10}$	$41\frac{3}{4}$	$41\frac{3}{8}$	$43\frac{9}{10}$	$46\frac{1}{2}$	$47\frac{1}{8}$	$47\frac{8}{10}$	$48\frac{1}{2}$	$49\frac{1}{8}$	49	$46\frac{7}{10}$
1867	$48\frac{1}{4}$	$47\frac{1}{2}$	$44\frac{3}{4}$	41	$42\frac{6}{10}$	43	$43\frac{1}{4}$	$43\frac{3}{4}$	$44\frac{1}{2}$	$44\frac{1}{2}$	44	42	$44\frac{1}{10}$
1868	$37\frac{7}{8}$	$36\frac{5}{8}$	$37\frac{1}{2}$	$38\frac{1}{3}$	37	$36\frac{7}{8}$	$38\frac{1}{3}$	$39\frac{3}{16}$	40	$41\frac{1}{8}$	$42\frac{1}{2}$	43	39
1869	$41\frac{5}{8}$	$40\frac{1}{4}$	$41\frac{4}{10}$	$39\frac{7}{8}$	$39\frac{1}{2}$	$40\frac{4}{5}$	$41\frac{3}{8}$	41	$40\frac{1}{3}$	$40\frac{1}{8}$	$39\frac{1}{4}$	$38\frac{1}{2}$	$40\frac{1}{3}$
1870	$36\frac{1}{4}$	$34\frac{1}{5}$	34	$32\frac{2}{5}$	32	$32\frac{1}{8}$	$32\frac{1}{8}$	33	$32\frac{3}{4}$	$31\frac{2}{5}$	$30\frac{3}{4}$	$30\frac{1}{8}$	$32\frac{7}{10}$
1871	$30\frac{1}{8}$	$30\frac{9}{10}$	$35\frac{1}{8}$	$34\frac{5}{8}$	35	$35\frac{1}{4}$	$35\frac{1}{4}$	$35\frac{7}{8}$	$36\frac{1}{4}$	37			

AMERICAN PIG.—The future course of the Iron market is daily becoming a topic of great and increasing interest to very many of our readers. The winter supply of many of them must be bought and delivered soon, or they must either be short of metal or pay heavy railroad freights after the close of navigation. A brief recapitulation of the chief features of the market, as they appear to us, is therefore appropriate, and may aid some to arrive at a wise decision. In the first place, the genuine feeling among buyers of iron is that prices are too high, and must break very soon ; producers, on the other hand, say that they are able not only to maintain present rates, but even to advance them, and $40 is freely spoken of as a probable price for No. 1 Foundry. The brokers generally take the view of the producers. In the beginning of this year American iron was lower than at any time since the price advanced from the ante-war rates, being quoted by us from January 12 to February 16 at $30 for Foundry No. 1. The coal strike, and consequent stoppage of most of the Anthracite furnaces, drained the market completely of iron, whether in the hands of producers, dealers or consumers ; and since the resumption of coal mining and iron production, the price has steadily advanced until, to-day, the quotation is $37 to $38—and this price may be fairly called nominal, there is so little iron to be had. The furnace companies have none. A gentleman who went carefully through the Lehigh district last week saw only about a thousand tons of iron on the furnace banks, and the most of that would not have been there but for the difficulty of getting cars to take it away. Dealers and speculators have very little iron ; and consumers, most of whom have ever since the advance been buying from hand to mouth, are very bare. Moreover, most of the furnace companies are largely oversold. The advance in price has been caused entirely by the short supply and a legitimate demand for consumption—the absence of speculation being one of its most marked features. If this demand for consumption continues, it seems to us inevitable that the price will be maintained, at least till after the close of navigation, and probably longer. Bearing on this point, we would remind our readers that the year 1870 began with large stocks in the hands of both furnace companies and consumers, which were very much reduced at the close of the year, showing that consumption was greater than production, notwithstanding the fall in price that occurred during the year. Then occurred the coal strike, which lessened the production of iron much more than its consumption ; and since, business has been very active in all the trades that consume iron. Indeed, this is true of all met ls used in staple manufactures, and prices of these metals have rapidly advanced. In fine, we think that iron ought to be purchased now by those who will need it soon. To our view, there is no sign of weakness in the market, and we inclide to the belief that, if nothing occurs to check the demand, there will not be the usual stocks of iron in the early months of next year. The advance in iron of all kinds has been as marked in Europe as in this country. —*Iron Age.*

SHEET-IRON stacks for heating and puddling furnaces are now being made in separate rings, instead of one whole length as formerly. Each ring has a band of flat bar-iron—horseshoe bar—about 2 in. from the lower edge, firmly riveted, and by which each is supported as it fits into and rests on the edge of the one next below. By making the stack in this way in short sections, it can be more conveniently erected, and also can be repaired by renewing any worn-out part or burnt

section at less cost, and much less labor, than when otherwise constructed.—*Am. Railway Times.*

Railway Iron in Russia.—It is a noticeable fact that the demand for British railway iron in Russia, although still respectable, has greatly declined in importance this year. The shipments of our railway iron to Russia have been as follows, month by month, to August 31, in the last three years:—

Month.	1869.	1870.	1871.
	Tons.	Tons.	Tons.
January		908	193
February	1,283	65	2,951
March	7,145	3,133	5,856
April	21,166	20,619	5,732
May	23,120	52,741	19,466
June	34,072	36,988	12,731
July	35,731	26,094	7,610
August	36,532	23,152	11,095
Total	159,049	163,700	65,634

It is this flatness in the Russian demand, coupled with a decline in the consumption of our railway iron in British India, which, as has been before observed, has occasioned the comparative dulness in the British railway iron trade this year, a dulness which would have been still greater but for the progress of consumption in Canada and the United States. The principal cause of the decline in the Russian demand for our railway iron is probably to be found in the new clause introduced into the concessions of Russian lines, by which their administrations are required to purchase rails and plant to as large an extent as possible in Russia itself. The Czar's Government is doing all in its power to develop metallurgical industry upon the Russian soil, and the effect of this policy has been felt still more strongly by the Belgian than by the English iron trade. Thus, the exports of Belgian rails to Russia in the first six months of this year declined to the comparatively insignificant total of 580 tons.

Nevertheless, the railway interest has now acquired such importance in Russia, and the results obtained from working the lines thus far completed have been so encouraging—the burthen of the guarantees of interest given by the Russian Government having only involved a loss to the Russian Treasury in its last financial year of 9,000,000 roubles, instead of 26,000,000 roubles, as had been estimated—that, in spite of every effort which may be made to develop the production of iron in Russia, a good consumption of English rails in Russia seems probable for some years to come. The Russians appear to take more kindly to English railway *materiel* than to Belgian, financial considerations having possibly something to do with the matter. Thus the Russian Government and Russian guaranteed railway companies have borrowed, and will probably yet again borrow, largely in England; and where they raise capital they are not unlikely to give out orders, at any rate to some extent. Moreover, Russia is still very slenderly supplied with railways. In spite of the energetic efforts put forth during the last four or five years, Russia had still only 11,032 versts, or about 7,400 English miles, of railway in operation at the commencement of July, 1871. It is true that on the same date there were 3,276 versts, or about 2,165 English miles, in course of construction; but it is not very difficult to see that even when all the new lines now on hand are finished off, and even when Russia has 9,565 miles of iron-way in a condition to admit of the passage of trains, she will still have an immense deal to do before she will have fully satisfied her railway requirements. Russia has copied rather slavishly the example of England in the matter of railways. Her guarantee system is borrowed almost literally from British India, and one of the latest acts of the Russian Government has been the appointment of a commission to consider the desirability of constructing a system of light and very narrow gauge railways in the Caucasus. England has thus not only a financial, but a moral influence even in Russia. The Russians look with a certain respect and wistfulness still upon Great Britain, and they would fain penetrate some of the secrets which have enabled her to accumulate such enormous wealth, and to develop the mechanical arts with such remarkable success. So long as such a feeling as this remains in the Russian mind we shall still, we may depend upon it, enjoy a certain amount of Russian custom.

With a continuance of peace, Russian railways must grow year by year in importance and extent. There are two opposing influences at work in Russia—the commercial instinct and the military instinct. The progress of liberal ideas is felt, however, even in Russia. The Czar is still a mighty and almost irresponsible potentate, but even Russian Czars succumb to the genius of the age, and become penetrated with the ideas and influences of modern civilization. As year by year the immense material advantages resulting from railways impress themselves more and more forcibly upon the Russian mind, there must be a call for more Russian railways. Instead of 9,565 miles of line, Russia would probably not be overdone with railways even if 30,000 miles of iron-way were constructed upon her soil. Under all the circumstances, we incline to the opinion that the commercial instinct will become more and more powerful in Russia, and that the Russians will continue for years to come to make more railways, and to consume considerable quantities of our railway iron.

RAILWAY NOTES.

An Old Locomotive.—A junk merchant here in Worcester is now knocking to pieces an old engine from the Hartford, Providence and Fishkill Railroad, which has stood the vicissitudes of nearly twenty-five years of almost constant service. Mr. Garfield, the master mechanic, informs me that it has run three hundred thousand miles, and that the copper tubes have never required repairs, except the plugging of three of the lower ones. They are 2-in., and are thimbled with cast iron at the fire end. The old machine is in a good state of preservation, the boiler nowise dangerously reduced in thickness.

But the most noteworthy matter about the old engine is the vast accumulation of yellowish scale at the bottom of the boiler. Several of the lower tubes are completely imbedded in this foul matter, and the water space around the fire-box is solidly

packed with it for a foot or so in depth at the bottom, except a small space around the blow-cock; affording unmistakable evidence that there should be a blow-cock at every two feet or less, not only around the fire-box, but beneath the cylinder part of the boiler.—*American Railway Times.*

COST OF RAILROAD TRACK MATERIAL IN NEBRASKA.—Herewith find a few notes relative to the cost of track material per mile in this State, compiled while the first sixty miles of this road was under construction, 1869–'70.

As the figures here given are not materially different from what they would be if revised for the present time, I would suggest that some young engineer employed on Eastern roads furnish you a similar statement, that a comparison may be made, of interest, probably, to many of your readers who have not the time to do it personally.

I will take up the items of rails, ties, spikes, and splices separately and in detail.

The iron for rails came from the Cambria Iron Works, Johnstown, Pennsylvania; had a weight of 57 lbs. per yard, and cost $78 per ton at the works. The freight per car load of 44 bars to Plattsmouth, the initial point of this road, was $187, or about $18.55 per ton additional, or a total of $96.55.

The rail being in 27 ft. bars, excepting a small amount for use on curves ordered 3 in. shorter, a mile of track requires about 391 rails or 89 56-100 tons gross, which at $96.55 per ton gives cost of iron per mile of track as $8,647.

The ties were of hewn oak and came from Central Missouri, principally, and were contracted for so that the price to the company at Plattsmouth was about $1.00 each, of which more than half was paid out by the contractor for freight.

These ties were of a superior quality, 8 ft. long, with 8 in. face. A car load contains from 130 to 150. They were laid 12 to a rail of 27 ft. in length, and, therefore, for a mile there would be 2,347, which, at $1 each, makes $2,347 per mile of track expended for ties.

The spikes used came from the American Iron Works, firm of Jones & Laughlin, Pittsburgh, Pennsylvania; dimensions 9-16 in. by 9-16 in. by 5 in., and cost 4 5-8 cents per pound at the works. These come in kegs of 150 lbs., each containing about 268 spikes. The freight per car load (150 kegs) was about the same as for iron, viz., $187, delivered at Plattsmouth. As the track is double-spiked, it takes 4 spikes to a tie, or 9,388 spikes to a mile, being 35 kegs, or 5,250 lbs. The cost, therefore, per mile for spikes will be: Cost of 35 kegs at works, $242.81, plus freight on same, $43.63, or a total of $286.44. The splices used were also from the Cambria Iron Works, and the price in detail at works, is as follows, per joint:

Fish bars, each 8 2-10 lbs.=16 4-10 lbs, at 3 5-8 c.	59 cents.
4 bolts, each 94-100 lbs.=1 88-100 lbs. at 6 c.	23 "
Total cost at works	82 cents.

The freight charges per car load (1,000 splices complete) being about the same as for spikes, viz., $187, and it taking 391 splices for a mile of track, we have for cost of same, $320.62 at works, plus $73.11 freight, or $393.73. To recapitulate, we have the following:

COST PER MILE OF TRACK FOR MATERIAL.

Rails	$8,647 00
Ties	2,347 00
Spikes	286 44
Splices	393 73
	$11,674 17

To the above must be added the expense of hauling, unloading, laying, surfacing, etc., to give total expended for perfect track, as well as the cost of frogs, switches, etc.—*Railroad Gazette.*

A NEW DOUBLE BOGIE LOCOMOTIVE.—A party of engineers have visited Bristol for the purpose of inspecting a new double bogie locomotive, constructed after the design of Mr. Fairlie. The engine "Hercules" is for the Iquique Railway in Peru. It has four 15 in. cylinders, of 22 in. stroke, and its total weight (60 tons) rests upon 12 wheels, arranged in 2 groups of 6, coupled together, and all assisting in the adhesion. It will be required to work heavy traffic over a gradient of 1 in 25 for 11 miles, and round curves of 3 chains; and during the experiments it went round curves of 2½ chains with the greatest facility, the deflection of the centre of the leading bogie platform from the end of the boiler amounting to 14 in. It was next taken through a boiler shop and a smith's shop, and so upon a very irregular and badly kept piece of line belonging to the Midland Company. Here its trip was interrupted by certain bridges and platforms which it could not pass; but it ran up and down, over a length of about a quarter of a mile, with perfect smoothness. Its passage over roughly laid points was distinctly heard by those riding upon it, but communicated no jolt to the driver's platform. It has been built by the Avonside Company, for Messrs. Montero, of Peru.

THE Hudson River and New York Central Railroad Companies have both adopted a new style of car to be used in the transportation of petroleum. Oil will hereafter be transported over the roads in fire-proof tanks, made of quarter-inch boiler-iron, fastened upon platform-cars. They are filled from a dome at the top, the main hole in which is to be securely fastened when the tank is filled. In case of an accident, it will hardly be possible for the oil to escape; for even in case of severe concussion, no considerable quantity of oil would be likely to escape.—*Am. Railway Times.*

IT is stated by an exchange paper that the Michigan Central and the Great Western road of Canada are virtually consolidated, an agreement for twenty years having been concluded, under which the entire earnings for through business are put into a joint purse and then divided. These are the roads that are to be connected by a tunnel under the river at Detroit.

THE property, rights and franchises of the North Missouri Railroad Company, are advertised to be sold on the 26th of August next, for the payment of $4,000,000, the sale to be subject to a prior mortgage claim of $6,000,000.

THE associated railways of Germany consist of 78 companies, owning 19,145 miles of road; 12 months previously the same companies owned 17,178 miles, showing an increase of 1,967 miles.

Fifty-six miles of the European and North American railway have been completed, which carries the track to "Winn," a distance of 56 miles from Bangor, Maine. The road is to be extended to Vanceborough, which is on the Canadian line. At this point a connection will be made with roads extending to St. Johns and Halifax, N. S., which will form a complete line from Halifax to Boston.

A number of heavy capitalists propose to span the Andes with a railroad, to connect the Argentine Republic witn Chili. The cost is estimated at $30,000,000.

Brigham Young and his people are waking up to the importance of railroad construction in their territory, and surveyors have been put to work on the route for the Utah Southern road. Mormonism will yield to the inevitable destiny of railway progress.

ENGINEERING STRUCTURES.

Performance of Steam Boilers.—Several steam boilers having been entered in competition at the Fair of the American Institute, just closed, the Board of Managers, with their usual liberality, consented to the adoption by the Committee of Judges on Steam Engines and Boilers, of a method of testing which should determine with certainty the relative economic value and steaming capacity of the competing boilers.

Accordingly, the Committee—Professor R. H Thurston, Chairman (of the "Stevens Institute of Technology'), T. J. Sloan and Robert Weir, members, have made such a test of the boilers on exhibition, as, perhaps, was never before attempted.

Under their direction, and under the immediate supervision of the Chairman of the Committee, a large tank was prepared in which about 1,100 ft. of 4 in. pipe was laid, and so arranged that the condensing water from the Croton pipes should flow through the tank, while steam from the boiler at 75 lbs. pressure was blown off into the pipes of this very effective surface condenser.

The pressure of steam, which varied between 70 and 75 lbs., was recorded by an Edson and a Davis recording gauge; the quantity of feed water and of injection, or tank supply, was measured by Tice and Worthington metres ; the water of condensation was carefully weighed, and the temperatures of feed and injection, steam, discharge water of tank and water of condensation, and that of the gases in the flues, were all recorded every ½ hour during 12 hours trial of each boiler.

At starting, each exhibitor was allowed to fire up with wood until a pressure of 75 lbs. was reached, when steam was let into the condenser, and the trial was, at that instant, considered as commenced, and firing began with coal. The weight of wood and time of making steam were entered on the log.

At closing, each exhibitor was allowed to burn his fires completely out, if he desired, provided that, at the close of the 12 hours, he had 75 lbs. steam, and the water in his boiler at a point marked at the beginning of the trial by a thread tied about the gauge glass. All that then remained on the grate was weighed back as ash. The meters were allowed to run until all heat was removed from the condenser, although steam was shut off from the condenser at the moment the 12 hours was expired by the Judges' time.

In calculating the results by this method, it is easy to determine, not only the evaporation per lb. of combustible, but also, with great exactness, the condition of the steam, whether wet, saturated, or superheated ; in the first case, the quantity of heat transferred to the condensing water will be less, and in the last case greater, than is due to the weighed amount of water of condensation, evaporated at the temperature and pressure in the experiment, as given by our tables for saturated steam.

The log was kept and observations made with great care,—in the presence of all parties interested who chose to attend the trial,—by Students Henderson, Hewitt, Poinier and Post of the classes of'73 and '74 of the "Stevens Institute of Technology" and under the supervision of the Chairman of the Committee, and every precaution was taken to insure correctness.

The results are said to be most creditable to the competitors, and exhibit in a surprising manner the accuracy of this method. They will be published after the Committee shall have completed the Reports in Department V., Group I.

Giant Chimney at Dovercourt.—There are few localities within an equal distance of London, 70 miles, which possess more intrinsic claims, as a summer retreat, than Dovercourt. It may be said to be a suburb of the thriving and bustling town of Harwich, and is destined eventually, and perhaps at no distant date, to become much better known, and more extensively patronized by visitors. The diversified land scenery within range of vision from its cliffs, and the intermingling of the waters of the Orwell with the German Ocean at the base of the promontory upon which it stands, constitute some of the attractions of Dovercourt.

One of the impediments to a perfect enjoyment of the delights of the neighborhood is at this moment in rapid process of removal. The pure air which naturally exists there has hitherto suffered some contamination from an intermixture with it of the fumes and smoke from a series of cement kilns, ranged in a line in close proximity to the neat little railway-station of the town. In order to obviate this sometimes too palpable annoyance, the owner of the kilns, which are fed with material dredged from the estuary of the Orwell, and from the west rocks near Walton-on-the-Naze, is causing a gigantic shaft to be erected. This is a remarkably well proportioned square built structure, formed of the hardest red bricks and the finest cement of the district. Its height, when finished, will be upwards of 190 ft., and it will form one of the most conspicuous, and in its way, handsome objects of the place. At its base, the giant chimney is 20 ft. sq., and, at its summit, capped with stone, it will be 8 ft. 6 in. across. Some idea may be gained of the large number of bricks used in the construction of the chimney, when it is stated that in a single course at its base 1,500 are comprised. A brick tunnel 100 ft. in length, and of large area, will connect the great landmark, for such it will be, with the apices of the various kilns. The fumes generated by the calcination of the cement stones will thus be carried to a height whence they will be distributed over a much wider area, and of course by

diffusion deprived of the power of irritating the lungs of visitors, and the tempers of the inhabitants of Dovercourt.—*Mechanics' Magazine.*

ORDNANCE AND NAVAL NOTES.

The German Naval Armaments.—The defensive works at the mouth of the Weser are to be strengthened by the erection of two new forts, one of which will be built on the Langlutjensand, about 6,000 ft. further down the stream than the works now in course of construction there, while the other will be situated in the vicinity of Bremen. When these are completed, the defences of the Weser will consist of four powerful works from which a double cross-fire might be opened on a hostile fleet. A steamboat has been sent from Kiel for the purpose of running between Geestemunde and Fort Langlutjensand, and as soon as the fortifications are complete the bridge which now unites the fort with the mainland will be broken down, and the former surrounded by water. The newly built screw advice-ships Nautilus and Albatross will next year join the German East Asiatic squadron, which will then consist of 4 vessels, with 48 guns. The Nautilus and the Albatross have been specially constructed and fitted up for this branch of the service, but the experience of late years has led to the conviction that it will be well to modify the plan of constructing a fleet exclusively of corvettes for this station, as in spite of the advantages arising from their superior speed, the comparative weakness of their artillery makes them much less formidable than the heavy, or even the middle-sized frigates of the English or the French navy. The question is therefore now under consideration, whether it may not be advisable to send one or two frigates of a middle size to the East Asiatic waters, which might then be accompanied by a number of swift advice-boats of light draft, but armed with heavy artillery, for the purpose of pursuing and destroying the pirate vessels which infest those seas. In the original plan, the place of the proposed frigates was to be taken by iron-clad corvettes, and the Hansa, now in course of construction, was intended for this purpose. The unwieldy character of the iron-clads, however, renders them but ill-suited for seas exposed to sudden and violent storms, bounded by dangerous coasts, and full of hidden rocks, where, too, in case their machines were injured or any other accident occurred, they could not be properly repaired. On the other hand, it does not seem advisable to diminish the small number of iron-clads which Germany has at her disposal, by sending one to so distant a station.—*Nautical Gazette.*

The 35-Ton Gun.—This splendidly constructed, but at present utterly useless weapon hangs heavily on the hands of the Admiralty. "What will they do with it?" is the question constantly asked, but never as yet answered. To make a good gun of it would be to proportion the length to the bore by adding about 2½ calibres to its length. But it has been built to Admiralty orders, and to the restricted dimensions necessary for a turret. No blame, of course, attaches to Colonel Campbell's department, but we should like to have seen the gun turned out some 28 in. longer, and then have been handed over to the Admiralty to cut down to their dimensions. But of course the gun factory had to work to specifications and drawings, and they are not responsible if the fault of the gun lies in its shortness, which we believe it does. A short time since, there was a talk of lengthening the piece, but then it would be useless for the very purpose for which it was built. So now it is to be re-bored from the present calibre of 11.6 in. to one of 12 in., with rifling of the same twist as at present. This, of course, will reduce the length of the powder charge, and if the Admiralty will only ignite the cartridge centrally, they may probably succeed in burning all the powder, and rendering the gun useful. We sincerely trust they will, but if they do not we confess our inability to suggest any other alternative than the lengthening of the piece, and applying it to another purpose than that of arming a turret ship. It is, however, a patchy way of settling the question after all, and the worst of it is that there are a number of these same guns in a like predicament.—*Engineering.*

NEW BOOKS.

Narrow Gauge Railways. By C. E. Spooner, C. E., F. G. S. London: E. & F. N. Spon. For sale by D. Van Nostrand.

This book, with its numerous maps and illustrations, presents the most complete information on the working narrow gauges.

A Treatise on the Resistance of Materials. By De Volson Wood. New York: John Wiley & Son. For sale by Van Nostrand.

This excellent work is a condensation of the ahthor's lectures before the engineering classes of Michigan University. Separate essays on kindred topics have appeared in pamphlet form at different times during the past few years, by means of which Prof. Wood has become favorably introduced to the engineering profession.

The present work, besides presenting in concise form the theoretical bearing of the subject, gives in full reports of the more recent reliable experiments upon materials of all kinds employed by engineers.

The separate topics are Tension; Compression; Flexure and Rupture from Transverse Strains; Shearing; Flexure; Transverse Strength; Beams of Uniform Resistance; Torsion; Long Continued Strains and Shocks; Limits of Safe Loading.

An appendix on Preservation of Timber closes the volume.

The text is illustrated by 122 wood-cuts. Both typography and engravings are well executed.

The work will prove exceedingly valuable, not only to working engineers, but to the *confreres* of Prof. Wood in the scientific schools.

Plattner's Manual of Qualitative and Quantitative Analysis with the Blow-pipe. By Prof. T. H. Richter. Translated by H. B. Cornwall, A. M., assisted by J. H. Caswell, A. M. New York: D. Van Nostrand.

This is the most complete manual of Blow-pipe Analysis ever published. Nothing of importance in the German edition has been omitted, while

several new tests, both qualitative and quantitative, have been added by the translators.

The rapidity and ease with which blow-pipe analyses are applied, has rendered the method popular with the assayers and prospectors of our mining regions. The demand therefore for instruction in this branch of applied science has steadily increased of late. The present work, containing 550 pages, is a complete encyclopedia of blow-pipe manipulation. We shall soon present a complete review of the work.

A Review of the Theory of Narrow Gauges as applied to Main Trunk Lines of Railway. By Silas Seymour. New York: D. Van Nostrand.

This review was called forth by the President of the Texas Pacific Railroad Company, who appealed to the author as a professional authority. The discussion is able and, though brief, exhaustive.

An appendix by S. S. Post, C. E., upon the comparative resistances of the curves of different gauges, enhances the value of the book.

Le Soleil. Par le P. A. Secchi. S. J. Paris: Gauthier Villars. For sale by Van Nostrand.

This treatise by the celebrated Roman astronomer will be gladly received by all who are interested in solar physics. 130 wood-cuts and 3 folding plates illustrate the work.

All the recent observations are brought to bear upon the discussion of the subject, which is thereby rendered the most complete that has been offered to the scientific world.

Logarithmic and Trigonometric Functions. By James Miles Peirce. Gwin Bros., publishers. For sale by Van Nostrand.

This is a collection of 3 and 4 place tables of logarithms and trigonometric functions, containing proportional parts of all numbers up to 100; 3 place tables of logarithms of numbers and of the 6 trigonometric functions, natural and logarithmic, all in one page; a useful table for obtaining rough results and first approximations; logarithms of numbers to 4 places; logarithms of sums and differences (Gaussian Logarithms) to 4 places; logarithmic trigonometric functions to 4 places; inverse trigonometric functions adapted to use with 4 place logarithms; a new table, for finding angles from the logarithms of their trigonometric functions; traverse table; the Correction of the Middle Latitude, in an improved form; Meridional Parts; and Constants, with their logarithms.

The publishers give assurance that the greatest pains have been taken to insure perfect accuracy. It is certain that they have furnished a set of tables, that economize the labor of working for tabular numbers, and save the eye all unnecessary perplexity and fatigue. The editor says:

"Experiments conducted several years ago at the office of the "American Ephemeris" resulted in the conclusion that the times occupied, in regular computation, in doing one piece of work by tables of 4, 5, 6, and 7 places, are proportional to the numbers 1, 2, 3, and 4. It will be seen, then, that 4-place tables have a great advantage over those even of 5 places, wherever the degree of accuracy of which they are susceptible is sufficient for the work to be done, or as great as the probable errors of the data will admit; as, for example, in all the ordinary computations of common surveying, engineering, and navigation, as well as those with which college students are generally occupied.

MISCELLANEOUS.

On the Influence of the Suez Canal on the Commerce in Coals of South Africa.—The "Natal Mercury" says that the construction of the Suez Canal will be an advantage to Natal, especially for the commerce in coals. It is quite true that the opening of the canal has entirely annulled the demand for coals along the coast near the Cape, and that steamers bound to and from India will no longer require to coal at any port in South Africa; but it is also true that steamers to and from Suez will have to coal at Aden, where the demand will soon be increased tenfold. If Natal can supply good coals, no doubt it will find a large demand at Aden. Indian coals are not suitable for steamers, and the coal from England cannot be brought to Aden economically; the supply must, therefore, necessarily come from the mines of the East, and consequently the coals of Natal will find a much better market than if the canal had not been constructed, especially if prepared in agglomerated blocks.—*Mechanics' Magazine.*

Mackie's Steam Justifier and Perforator.—As an important adjunct to his steam type-composer, Mr. Mackie has exhibited during the past month, at the International Exhibition, what he calls his "steam justifier and perforator." The machine is very small and simple. Over the top of a row of punches is made to pass a series of "logos," made of zinc, each representing a letter, word, or sentence. In their passage they actuate the proper punches, so as to secure the exact number of letters and spaces in any line required. It works at the rate of 450 letters a minute, and will be three or four times that speed for Mr. Mackie's 40,000 an hour composer. The ordinary workman will soon learn to pick up these "logos," which are about the size of advertisement rules, and in cases laid much in the ordinary way. Speed, however, can only be secured by the workman using combinations, which he may increase to any extent. Each "logo" represents 3½ letters on the average. It is astonishing how accurately Mr. Mackie's plan secures "justification." So many "logos" weigh exactly the length of type required, and can be varied to a thin space.—*Mechanics' Magazine.*

Slag Cement.—The composition of the slags of the blast furnace should be for the most part as follows, to obtain from them a good cement. Essential elements: silicic acid, 40.28; clayey earths, 15.13; calcareous earths, 36.24. Non-essential elements: manganese, oxide of iron, alkalies, etc., 8.35 One part of these slags in fine powder is sprinkled, and agitated in a suitable vessel, with two parts of an equal mixture of hydrochloric acid (35 per cent HCl) and water. The slags decompose, a lively disengagement of HS taking place. The mass finally forms a thick jelly, from which water removes the chlorides completely. After removing these, the residue is dried and reduced to an impalpable powder; one

part of this powder, intimately mixed with nine parts of slags in powder, gives an excellent cement in water or air, as it may be desirable to apply it. —*Am. Railway Times.*

The Washing of Canal Banks.—Much attention has lately been attracted to a plan of protecting canal banks against washing, proposed by Mr. Lawrence Myers, of Philadelphia, and which is one of the inventions brought out by the offer of a State bounty for a successful method of steam canal navigation. Mr. Myers proposes to clothe the sides of the banks of canals with iron plates, $\frac{1}{8}$ in. in thickness, securely fastened, and suspended about equally above and below the water line. The object of this is to prevent injury to the banks from the wash of passing boats, and the device would be a very good one if there were any serious wash to obviate. As it is, however, the invention is designed to meet an imaginary necessity, so far as the Erie Canal is concerned. It may be that, on some canals, the banks are injured by the wash of which we hear so much, although we have never seen an instance in which such was the case; but the Erie and other New York State canals suffer no such damage, nor is it either necessary or desirable to take the banks into consideration in seeking a solution of the question of steam navigation. This is a mistake which inventors persist in making, notwithstanding the assurance of the Canal Commissioners and the Commissioners of the State bounty, that no possible injury can be done to the banks by any system of propulsion which is mechanically adapted to the business of the canals. If this could be impressed upon the minds of those who are designing and building steam canal boats, many of the imaginary difficulties would disappear, and inventors would be saved the trouble and expense of making costly and useless experiments. If sufficient power is provided for economical traction, the banks will take care of themselves.

Sounding the Baltic.—The "German Correspondent" says the steam advice ship Pomerani returned from her cruise in the Baltic on the 24th of August. After running from Stockholm to Gothland she anchored on the 20th July in the harbor of Wisby, a little town which lies among the ruins of ancient churches and the towers of fortifications of an earlier age. The Pomerania sailed eastwards till she approached the Russian coasts, and afterwards returned to Gothland, and thence to Memel. She crossed the deepest part of the Baltic in three different directions, steamed along the Prussian coast to Daustic, and then examined the Baltic between the coasts of Pomerania, Gothland, Oeland, and Rügen. After coaling at Straland she rounded the Cape of Arkona in Rügen, and passed to the west along the coast of Pomerania, Mecklenburg, and Holstein. During the whole of these journeys soundings were carefully taken, the bottom dredged, the surface and deep-water currents observed, and the temperature of the water at the surface and at some depth, as well as the proportion of salt it contained, determined. The results of these observations will be published after they have been subjected to proper scientific examinations. The greatest depth of the Baltic between Gothland and Windau was found to be 720 ft., not 1100 ft., as was formerly supposed. At the depth of from 600 ft. to 720 ft. the water was, at the end of July, very cold, the thermometer giving from $\frac{1}{2}$ to 2 deg. R. No plants were found at this depth, and only a few specimens of 1 or 2 species of worms were brought up with the clay and mud. The cold probably prevents fresh-water animals from living at such a depth, while the small quantity of salt which the water contains renders it unfit to support sea animals. Animal life abounds from the surface to about 300 ft, below it, while plants were seldom found at a depth of more than 60 ft. The Baltic is supplied with salt water by the Kattegat, through which a deep-water current flows into the Baltic, while the brackish water, which is lighter, streams into the North Sea by a surface current. Both animal and vegetable life, was found to be most abundant on the coasts of Mecklenburg, Schleswig, and Holstein, and in the Bay of Lubeck.

Novel Mode of Utilizing Sewage at Glasgow.—Although Glasgow is far behind London in regard to its sewage arrangements, yet it is about to adopt a plan for utilizing part of its sewage, which now runs into and pollutes the Clyde, that London might very well follow, if the several municipal Boards were only to take joint action in the matter. A contract has just been entered into between the Sanitary Committee of the Police Board of Glasgow and a company in that city for utilizing the urinals. The Police Board are to collect and supply to the company 5,000 gallons per day for 12 years, for which the company are to pay the Police Board £1,000 per annum. It will be collected in close tanks, and will be removed during the night to the company's works, where it will be resolved by a chemical process into sulphate of ammonia. The contract is to take effect from the beginning of next year.

Engineering Schools in Italy.—The number of engineering schools (or as they are termed, schools of application for engineers) in Italy are three. During the scholastic year 1868-69 the numner of diplomas granted was 656, being 395 at Milan, 79 at Naples, and 182 at Turin. At the University of Padua there is also a course of engineering, but only two diplomas were granted during the above-mentioned years. The total number of students entered on the books of these schools during the scholastic year 1869-70 was 567, of whom 190 were registered at Turin, 135 at Naples, and 242 at Milan.

The Rolling of Gunboats.—The gunboats Bustard and Kite (of the Blazer class), in charge of Captain Charles Fellowes and Staff, of the Steam Reserve, were taken into the offing at Plymouth on Friday, in order to test their rolling motion in a sea way, and discover whether it is easier with the 18 ton in its position on the platform level with the fore-deck, or when it is lowered into the well beneath; and although the weather was not sufficiently rough to subject the vessels to a severe test, yet the result showed that they are much steadier when the gun is up in its position than when it is below. The wind was N. W., force 2, with a moderate sea. The Bustard, with her gun on deck, made only 11 rolls per minute, and the greatest roll was from 7 deg. to port (leeward) to 4 deg. to starboard (windward), but with the gun below she made 14 rolls per minute, the greatest roll being from 9 deg. to port to 13 deg. to starboard, being

3 rolls per minute more with just twice the amount of heel. A similar result was obtained with the Kite.

New Process of Casting Water and Gas Pipes. —The San Francisco "Scientific Press," in a late issue, says: "We were much interested, on Friday last, in examining at the foundry, corner of Harrison and Main streets, a new process which has recently been introduced on this coast, for the casting of water and gas pipes. This process, which is the invention of, and has been patented by John Farrar, of Boston, Mass., consists in the substitution for the ordinary clay moulds, of a sectional three part, cast iron flask, attached together with hinges, and secured by strong wrought-iron clamps. The inside of the flask (which constitutes the mould) is lined up with a preparation of fine clay and plumbago, secured in place by flanges, and which effectually resists the action of heat, over 600 having been cast from one flask without retiring. The flasks were ready for use, and suspended on trunnions, one end projecting over a pit. The process of casting consists of putting in place a core, clamping the flasks and hoisting it up on end; the molten iron is then poured in at the top, filling the space between the core and the flask, and thus forming the pipe. As soon as the metal has 'set,' the flask is brought down to a horizontal position, opened, and the pipe taken out. The lining of the flask is then washed with a preparation of black lead, laid on with large paint brushes, when the process ot casting is immediately repeated.

"An average of about 5 pipes an hour is thus made from each flask while the heat lasts, which usually contmues from 2 to 3 hours. On the occasion referred to, 3 flasks were alternately used by a gang of 18 men, who turned out a pipe about every 5 minutes.

"The advantages of this processs are: The flask makes a permanent mold, admitting of the casting of an indefinte number of pipes without renewal; uniformity in thickness, secured by equal pressure upon the core-barrel, and a close texture of metal and absence of sand holes—porous places which are inevitable where it is cast horizontally. Messrs. Rankin & Brayton, the proprietors of these works, have now 4 flasks in position, from which they are casting from 500 to 600 ft. per day of 4, 5, and 6 in. pipe. Other flasks, embracing all the usual sizes, will soon be in readiness, giving the works a capacity of 1000 ft. per day.

"The usual process for making pipe in the East is that of the ordinary sand mould, which requires an iron flask for each pipe, necessitating a large outlay for the equipment of a foundry of any capacity. The extraordinary advantages of this process are apparent, when it is seen that no moulding is required, and one flask is made to do the work of 12 or 15 on the old plan. This invention is justly regarded by iron men as the most important improvement introduced into this branch of the foundry business. The gentlemen above named have secured the exclusive use of the process for this coast, and the very remarkable facilities it affords will enable them to compete successfully with either Eastern or European manufactures, thus adding another most important and useful industry to our list of local manufactures. Some idea of the saving which this invention will secure to this State may be formed from the fact, that something like 60 miles cf pipes are now on the way from the East to this city; but that, in view of the improved facilities hereby offered, no Eastern firm can hereafter afford to enter into competition with the work here. The inventor having made the demonstration here complete will soon go East to introduce the process into the larger Eastern foundries.

"The above firm have been engaged for several months past in filling large pipe orders for the Metropolitan Gas Co., of this city, including some 2 miles of 16 in. drain, now being laid from Montgomery street to the works, corner of Ninth and Brannan. They have also additional orders in hand for some 20 miles of pipes, of various sizes, for the same company, as well as several orders from the interior gas and water companies."

Blasting Timber with Dynamite.—Last year at the commencement of the war, a tremendous storm inflicted much damage in the great forest of Haye (Meurthe-Moselle). The ground being weak, and the wind exerting a great force against the tops of the trees, a large number were thrown down. Recently the State has taken steps to sell these fallen trees by public auction. The stumps were taken off with the saw, and the trunks were cleared and raised. The beech-roots having become very hard by a long exposure to the air, they could not be cheaply removed and there remained on the ground a very large amount of timber. An engineer thought of applying the method that had been followed with success in similar cases in Germany; recourse was therefore had to dynamite. In each root, and following the axis of the tree, a hole was drilled with an auger from 9 in. to 15 in. deep, and ¾ in. diameter. A dynamite cartridge, of about 50 grammes, provided with a fulminating cap and a length of ordinary mine fuse, was placed at the bottom of the hole. When the charge was tamped the explosion was made, which divided the root into quarters, after which it was easy to reduce it by ordinary means into convenient sizes. By aid of this arrangement each woodman was able to break up 2½ cubic yards a day, with an expense of about 3f for dynamite, implements, and hand labor. In this manner profitable results were obtained from timber which would otherwise hsve been abandoned.

Surface Movements of the Earth.—M. de Botello describes two contemporary upheavals of the earth's surface, entirely authentic. In the Province of Jamora, it is observed that, from the village of Villar don Diego, it is now possible to see the upper half of the Church-steeple of Renifarzes, a village in the province of Valladovid; whereas, 23 years ago, in 1847, the summit of this steeple could only just be perceived The same thing occurs to the same degree and under the same circumstances, in the Province of Alava; there it is observed that, from the village of Salvatierra, the whole of the village of Salduende can now be seen, while in 1847 the vane of the steeple could hardly be perceived. The four points mentioned are on the line which would pass by Burgos, and in the direction W. 28 deg 39 min. S., to E. 28 deg. 39 min N., that is to say, sensibly parallel to the system of the Sanserrois. A distance of about 140 miles separates the extreme points of the line of upheaval.

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